ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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And Auxiliary Machinery as supplied to the Admiralty. 2170

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See Illustrated Advertisement Page 11.

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6770
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7182
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PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
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Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3541
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See page 17, Oct. 3. 7263

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7183
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Drop Forgings
write
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Specification and Workmanship equal to Main Line Locomotives.
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Tested out on the High Seas in Naval Ships. 7854
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7379
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"Spencer-Hopwood" Patent Boilers.
Sole Makers:
W. H. SPENCER & CO., HITCHIN, HERTS.
See page 15, Oct. 3. 7454

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Henry Wells Oil Co.,
11, Haymarket, LONDON, S.W. 1.

Iron and Steel
Tubes and Fittings.
6930
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 109.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } Row's Patents.
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Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5732

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IRON AND STEEL.
Stewarts and Lloyd's, Ltd.,
41, OSWALD ST., GLASGOW.
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MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—135, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHERCROFT STREET, and 10, COLESHILL STREET.
See Advertisement page 25. 7360

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ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to AERATORS LTD., Edmonton, London, N. 18.

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are foremost as fire fighters. No Acids. No Alkalis. Safe to use and always ready.—BRITISH FIRE APPLIANCES Co., Ltd., 109, Victoria St., London, S.W. 1.

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ENGINEERING, IRON AND STEEL WORKS
Valuers.
CONSULTING ENGINEERS, REFEREES, AND ARBITRATORS.
Established over 50 years. 7100
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Locomotive Traversers
(ELECTRIC).
7189
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Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See Illus. Advt. last week, page 15. 7977

Patent
See's Hydro-Pneumatic Ash Ejector.
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 45, Billiter Bldgs., Billiter St., London, E.C. Od 4525

Separators
— FOR —
EXHAUST STEAM TURBINES COMPRESSED AIR, &c.
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METALLIC PACKINGS.
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Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

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STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.
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See Advertisement page 90, Oct. 10. 2409

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Works: BURNT MILL, near HARLOW, ESSEX.
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KINNING PARK HYDRAULIC FORGE, GLASGOW.
PATENTEES AND ORIGINAL MAKERS OF McNEIL'S PATENT MANHOLE DOORS.
SEND US YOUR ENQUIRIES.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
7940
See half-page Advertisement page 98, Oct. 3.

B. & S. Massey, Ltd., MANCHESTER.
Steam Hammers,
Power Hammers,
Drop Stamps,
Band Saws. 7330
QUICK DELIVERY. LARGE STOCK.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

The National Foremen's Association of the Engineering and Allied Trades.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 830

All communications to— H. W. Rhid, General Secretary. Head Offices— 81, High Holborn London, W.C.1.

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A COURSE OF LECTURES WITH PRACTICAL WORK ON PETROL ENGINES will be given on WEDNESDAYS, 7.15 to 9.45, by W. J. Stern, A.R.C.Sc., B.Sc., D.I.C.
Course commences October 15th.
Fee 10s. A 917

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Several prizes. Sec. "D" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7484 Offices of Engineering.

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Inst.C.E., Inst.Mech.E., and all Engineering Exams.

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THURLES URBAN COUNCIL, CO. TIPPERARY, IRELAND,
are prepared to consider

Tenders for:—One Steam

ROLLER, 12½ tons, and
ONE STONE CRUSHER, size 14 in. by 8 in. Mounted on Wheels, with Screen, Platform, &c.
Roller to be fitted with Governors and Pulley to carry belt for working stone-crusher, and with connection on top for working a Rock Drill.
Tenders to B. JACKMAN, Clerk of Urban Council. B 10

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of

LOCOMOTIVE ENGINES & TENDERS.
Two Double Bogie Tank Engines complete. "B" class.
Three Engines, with tenders complete. "O" class.
Specifications and Forms of Tender may be obtained at the Company's offices.
Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Locomotive Engines and Tenders," must be left with the undersigned not later than Noon on Tuesday, the 11th November, 1919.
A charge, which will not be returned, will be made of 40s. for each copy of Specification. Copies of the drawings may be obtained at the Office of Robert White, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W. 1.
By Order,
W. B. REYNOLDS.
for Managing Director.
Finsbury Pavement House, London, E.C. 2,
8th October, 1919. A 943

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.

Boring Lathes for Sale by PUBLIC TENDER.

Two 15½ in. centre, single-ended, straight bed, Boring LATHES, length of bed 32 ft. 6 in., belt drive, six positive feeds through gear box.
Makers:—T. White & Co., Paisley, Reference No. M.K. 7891 & 2.
One 13 in. centre Boring LATHE, cast-steel face-plates, provided with four adjustable jaws, driven by 30 B.H.P. motor, 220 volts, D.C., total length over bed 68 ft., approximate weight 36 tons. Makers:—Craven & Co., Manchester. Reference No. M.K. 7890.
Lying at Messrs. Walter Somers & Co., Heywood Forge, Halesowen.
Tenders for the above must be received not later than Ten a.m. 25th October.
Tender Forms and Permits to view, and all further information can be obtained on application to the CONTROLLER, D.B.I.o., Charing Cross Embankment Buildings, W.C. 2.

NOTE.—*Surplus*, price 3d., the official list of Government property for sale. Published twice monthly. On sale everywhere. A 888

MINISTRY OF PUBLIC WORKS, EGYPT.

BATRA PUMPING INSTALLATION.

The Ministry of Public Works, Egypt, invite

Tenders for the Supply, DELIVERY, ERECTION and FIXING of the MACHINERY and APPLIANCES

necessary for the complete equipment of a pumping installation at Batra in the province of Gharbia.
Tenders will be received by the DIRECTOR-GENERAL, Mechanical Department, Ministry of Public Works, Cairo, not later than noon on the 15th December, 1919, and will remain open for three calendar months.
Copies of the Conditions of Tender, Form of Tender and Specification may be had on application to Sir A. L. WEBB, K.C.M.G., Inspecting Engineer to the Egyptian and Sudanese Governments, Queen Anne's Chambers, Westminster. Price 10s 3d. B 56

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

	Specification Fees
1.—Laminated Springs, etc.	£1 0 0
2.—Steelwork for Bridges	10s. 0d.
3.—Helical Springs	5s. 0d.
4.—Water Cranes	5s. 0d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Laminated Springs, etc.," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 28th October, 1919.
The Directors do not bind themselves to accept the lowest or any Tender.
B. H. WALPOLE, Secretary.
Company's Offices, 48, Copthall Avenue, London, E.C.2.
16th October, 1919. B 34

METROPOLITAN WATER BOARD.

TENDER FOR PIPE-LAYING, REPAIRS, ETC.

The Metropolitan Water Board invite

Tenders for Pipe-Laying,

Repairs, etc., for a period of six months, commencing 1st December, 1919.
Tenders must be made on official forms which may be obtained from the offices of the Board, Chief Engineer's Department, South Place, Finsbury Pavement, E.C. 2, on or after Thursday, 16th October, 1919, by personal application or on receipt of a stamped addressed brief envelope.
Tenders enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, South Place, Finsbury Pavement, E.C. 2," endorsed "Tender for Pipe-laying, Repairs, etc.," must be delivered at the Offices of the Board, not later than 11 a.m. on Wednesday, the 29th October, 1919.
The Board do not bind themselves to accept the lowest or any Tender.
A. B. PILLING, Clerk of the Board.
2, South Place, Finsbury Pavement, E.C. 2.
13th October, 1919. B 15

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY OF CAST-IRON PIPES.

The Metropolitan Water Board invite

Tenders for the Supply of CAST-IRON PIPES and IRREGULAR CASTINGS,

for a period of Three Months, commencing 1st November, 1919.
Tenders must be made on official forms, which may be obtained from the Offices of the Board, Chief Engineer's Department, South Place, Finsbury Pavement, E.C. 2, on or after Thursday, the 16th October, 1919, by personal application, or on receipt of a stamped addressed brief envelope.
Tenders, enclosed in sealed envelopes, addressed to "The CLERK OF THE BOARD, Metropolitan Water Board, South Place, Finsbury Pavement, E.C. 2," endorsed "Tender for Cast-Iron Pipes," must be delivered at the Offices of the Board, not later than Eleven a.m. on Wednesday, the 29th October, 1919.
The Board do not bind themselves to accept the lowest or any Tender.
A. B. PILLING, Clerk of the Board.
2, South Place, Finsbury Pavement, E.C. 2.
13th October, 1919. B 14

COUNTY COUNCIL, TIPPERARY, N.R. (North Riding) invite

Tenders for the Supply of the Undermentioned MACHINERY and ROAD APPLIANCES:—

No. 5. Five-ton Compound Steam MOTOR TRACTORS, fitted with pump, injector, winding drum and rope, water elevator and hose, with awning full length of engine, 12in. wide driving wheels, and governors for driving fixed or stationary machinery.
No. 1. 12 in. by 8 in. Portable STONE BREAKER, with tilting screen, punched with ¾ in. and 2 in. round holes and an outer steel gauze for separating the dust.
No. 3. Three-bunk SLEEPING VANS, with top ventilator complete, without bedding, and fitted with springs, coal bunk, &c., &c.
No. 4. Six-ton End-tipping WAGONS, body 8 ft. 9 in., 6 ft. wide, and 2 ft. deep, complete, bottom sheeted with ¼ in. steel.
No. 1. 250-gallon WATER CART, 4 in. bore pump, suction hose, detachable drawbar for shafts, &c.
Above machinery to be similar in every way to that already in use by the County Council, Tipperary, N.R., and to be tendered for in accordance with the Conditions, which may be seen at the County Surveyor's Office, Court House, Nenagh, Co. Tipperary, any day up to Saturday, 15th November next, between the hours of 10.30 a.m. and four o'clock p.m.
Contractor to state date of delivery in his Tender.
Tenders to be lodged in the Office of the Secretary of the County Council, Tipperary, N.R., Court House, Nenagh, not later than Tuesday, 18th November, 1919. Envelopes to be endorsed "Tender for Machinery."
The lowest or any Tender not necessarily accepted.
The probable number required of each class of machinery is above given, but the County Council reserve to themselves the right of purchasing a lesser or greater number of each at their option.
By order,
R. B. BAYLY, County Secretary.
Court House, Nenagh. B 6

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of Engineering.

BRADFORD EDUCATION COMMITTEE TECHNICAL COLLEGE.

DEPARTMENT OF MECHANICAL AND CIVIL ENGINEERING.

Applications are Invited for

the following appointments:—
LECTURER IN MECHANICAL ENGINEERING. Engineering degree or equivalent qualification and drawing office or works experience essential. Commencing salary according to qualifications, but not less than £380, which includes the present war time bonus of £78 per annum, rising to £480 by £15 annually.
ASSISTANT LECTURER AND DEMONSTRATOR IN MECHANICAL ENGINEERING. Technical training with degree or diploma and drawing office or works experience essential. Salary £230, rising to £430 in accordance with scale. This includes the special bonus of £78 payable at the present time.
Full particulars and form of application may be obtained from the PRINCIPAL of the College.
BY ORDER. A 848

ROYAL AIR FORCE.

TEMPORARY EDUCATIONAL APPOINTMENTS.

The Services of Ten TEACHERS are REQUIRED for

duty in the Royal Air Force Training Establishments for Boy Mechanics.
Candidates should be qualified to give instruction in some or all of the following subjects:—
Practical Mathematics.
Applied Mechanics.
General Elementary Science.
Mechanical Drawing.
English and Civics.
Salary at the rate of £260 per annum.
Applications, together with copies of not more than three recent testimonials, and a statement of age, educational training, qualifications, and experience, together with the names of two referees, should be forwarded to the SECRETARY, Air Ministry, Kingsway, W.C. 2, on or before 18th October, 1919. A 816

NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.

RUTHERFORD TECHNICAL COLLEGE.

Applications are Invited for

the APPOINTMENT of Head of the Mechanical and Marine Engineering Department. Salary £500 per annum rising by annual increments of £25 to £600 per annum. Candidates should have the following qualifications:—
Good training at a University or Technical College with University degree or its equivalent, good workshop and drawing office experience in the manufacture and design of modern engineering appliances (including marine engineering), good experience in the testing of machinery and materials in modern laboratory work. Some teaching experience is also desirable.
Application Form and Conditions of Appointment may be obtained by sending stamped addressed foolscap envelope to the undersigned. Last date for the receipt of applications, October 20th.
THOS. WALLING, Acting Director of Education.
Education Office, Northumberland Road. B 20

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc., A.R.C.Sc., A.M.I.C.E., Principal.

Applications are Invited for

the following VACANCIES on the Staff of the Engineering Departments of the above College.

(a) CHIEF DRAUGHTSMAN.
The person appointed will be responsible for the control of the Engineering Drawing Office and the instruction given in this subject to Day Engineering Students. He will also be required to design various classes of machinery and scientific apparatus as is from time to time required.
It is regarded as essential that candidates shall have received a good engineering and general education, shop experience, and have held an executive position in the Drawing Office of an Engineering Works of repute.
Commencing salary £350 per annum.

(b) AUTOMATIC SHOP SUPERINTENDENT.
Candidates must have received full workshop training and be familiar with the operation of all classes of Automatic and semi-automatic Turning and Screwing Machines.
Commencing salary £300 per annum.

(c) ASSISTANT INSTRUCTOR IN GENERAL MACHINE SHOP.
Candidates must have received a full workshop training and be conversant with all classes of machine tools.
Commencing salary £235 per annum.

(d) ASSISTANT INSTRUCTOR IN ELECTRIC FITTING AND SWITCH-GEAR DEPARTMENT.
Candidates should possess theoretical and practical knowledge of the manufacture of switch gear, dynamos, etc.
Commencing salary £235 per annum.
Applications, together with copies of not more than three recent testimonials, should be sent to the PRINCIPAL, at the College, not later than the 24th October, 1919. A 805

UNIVERSITY COLLEGE, NOTTINGHAM.

DEPARTMENT OF ENGINEERING.

Applications are Invited for

the Post of Lecturer in Mechanical Engineering. The Lecturer must be specially qualified to conduct classes in Machine Drawing. Salary £250 per annum.
Particulars and forms of application, which must be returned not later than October 27th, may be obtained from the REGISTRAR. B 46

ARMSTRONG COLLEGE.

NEWCASTLE-UPON-TYNE.

PROFESSORSHIP OF ENGINEERING.

The Council invites

Applications for this Professorship,

now vacant owing to the retirement of Professor Weighton.
Candidates should be men of high attainments both in an educational and in a professional sense, and must have special qualifications and experience in Marine Engineering. Age not to exceed 40 years. Salary will commence at £1250 per annum. Ten copies of applications and of not more than three testimonials must be sent so as to reach the REGISTRAR, Armstrong College, *not later than October 21st, 1919.* A 909

SECOND ASSISTANT ENGINEER.

THE METROPOLITAN ASYLUMS BOARD Invite

Applications for the Appointment of SECOND ASSISTANT ENGINEER

on their Head Office Staff. Applicants should be of good education, and be well-trained mechanical and electrical engineers, who have served their time with first-class engineering firms, and should have good theoretical, scientific, and engineering knowledge. The Candidate appointed will be required to assist in the general supervision of the economical working and upkeep of a large number of steam boilers, steam engines, deep well-pumping plants and heating and hot-water supplies, and of laundry and kitchen machinery and appliances. Salary £220 per annum, rising by £20 annually to £350.
Application forms can be obtained from the undersigned and must be returned, accompanied by copies of testimonials, not later than 5th November, 1919. Envelopes to be endorsed "Application for Second Assistant Engineer."
DUNCOMBE MANN, Clerk to the Board.
Office of the Board, Embankment, E.C. 4. B 17

MUNICIPAL CORPORATION OF THE CITY OF BOMBAY.

APPOINTMENT OF ACTING EXECUTIVE ENGINEER.

The Municipal Corporation of the City of Bombay are prepared to receive

Applications for the Appointment of Acting Executive ENGINEER

for the Municipality, under Section 74 of the City of Bombay Municipal Act.
2. The minimum monthly salary of the appointment is Rs. 1200, and the maximum Rs. 2000.
3. The services of the selected candidate will be entertained for at least five years. If the acting arrangement is terminated before that period, he will, if willing, be employed in another capacity as a Municipal Engineer for the remaining period on the same salary.
4. The appointment is subject to confirmation by the Local Government. The incumbent must devote his whole time and attention to the duties of his office. He is liable to removal during his term of office for misconduct, or for neglect of or incapacity for his duties on the votes of not less than two-thirds of the Councillors present at the meeting of the Corporation.
5. Applicants should have knowledge of Municipal Engineering in all its branches, including Drainage, Roads and Buildings, Lighting, Electricity, and be able to supervise the various departments employed in the Engineering works of a large city.
6. If, as is probable, the selected candidate is taken on the permanent establishment of the Municipality, he will be eligible for pension under the Pension Rules of the Bombay Municipality, information regarding which and regarding leave rules can be obtained on a reference to the undersigned in Bombay or to Mr. W. D. Sheppard, C.I.E., 16, St. James Square, London, S.W. 1.
7. Applicants should state the minimum initial salary (in Rupees) within the limits above-mentioned which they are willing to accept.
8. Applications, which should be accompanied by "copies only" of testimonials and certificates of age and physical fitness, should be addressed to the undersigned, and forwarded as follows:—
(a) By applicants in Europe: to the care of Mr. W. D. Sheppard, C.I.E., 16, St. James Square, London, S.W. 1, so as to reach him not later than 1st November, 1919.
(b) By other applicants: to the Municipal Office in Bombay, so as to reach the undersigned not later than the 1st November, 1919.
R. P. MASANI, Municipal Secretary.
Bombay, 3rd September, 1919. A 949

Works Manager Required

immediately, for Gas Meter Works in Oldham. Must have good general Engineering Training, with experience in Station Meters, Governors, Wet Consumers' Meters and repairs, accustomed to modern methods of works organisation. Firm and tactful in dealing with men.—Apply by letter only, giving age and full particulars, to BOX No. 1795, care of Messrs. R. F. White & Son, Genl. Advg. Agents, 33, Fleet Street, E.C. 4. A 978

As Works Manager for Steel

Foundry engaged on repetition work, an ENGINEER with good foundry experience who has proved his capacity for management. An excellent opening for an energetic man conversant with modern methods.—Applicants should send full particulars of their qualifications, with age and salary required, to THE NATIONAL STEEL FOUNDRY (1914), Ltd., Kirkland Works, Leven, Fife. A 886

Estimator Wanted for Engineers' London Office, Junior, experienced,

knowledge of conveyor and structural work essential.—Address, A 965, Offices of Engineering.

THE CRUX OF THE TOLERANCE QUESTION.

By H. S. ROWELL.

STANDARDISATION invariably involves past and future practice, and sometimes the work of more than one branch of industry is affected. In standardising systems of tolerances many and various details require consideration, so that no excuse is needed for any attempt to direct attention to those points that matter most.

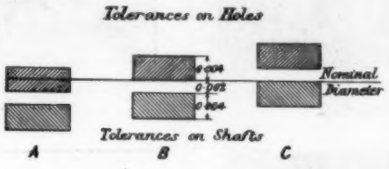
The amount of tolerance on machine parts must clearly depend on the nature and class of the work, and on the diameter of the parts in question. Work, however, is so varied in quality and character and size that the devising of any simple system which will fit existing conditions and yet keep pace with developments, becomes a formidable task. As a first step towards a rational and comprehensive scheme it is desirable to examine the simple geometry of the problem and to lay down if possible, the manner in which the tolerances shall be arranged, leaving out of account for the moment the more complex question of their amounts and variations. That is to say, before deciding on the measurements to be made, first fix the datum point from which they are to be measured. It is a matter for much satisfaction that the British Engineering Standards Association are adopting this course, and in order to gain the views of industry on this subject a committee of that body has issued a circular questionnaire form of referendum. The circular purports to give a summary of the various arguments for and against the systems under discussion. The arguments which have been considered by the committee, are, in the opinion of the writer, possibly in order to avoid any suspicion of prejudice, presented with an excessive impartiality. Thus some additional points which appear to merit attention, are set out below.

In dealing with this matter the influence of diameter, or of quality of work on the amounts of the tolerances will be ignored; on these points reference may be made to the issue of this journal for June 13, 1919 (page 760). Thus for purposes of discussion we may consider one diameter only, say 1 in. In the diagram are shown three sets of rectangles (A, B and C) which illustrate the tolerances on holes and shafts according to three systems. In A we have a system, much used at present, where the nominal diameter is the mean diameter of the whole. In B, the system recommended by the Standards Committee, the nominal diameter is the minimum limit of the hole, and in C, a system adopted some years ago by the electrical industry and followed more recently, and very regrettably, in the writer's opinion, by the Standards Association, in connection with screw threads (*cf.* Report No. 84), the nominal diameter is the maximum limit of the bolt.

For the sake of brevity and clearness we may ask how far each of these systems possesses superiority in respect of notation or manufacture or use. These three things are no doubt often inter-related and they are generally important; even notations alone have keen champions, as may be seen in the periodic revivals of metric system propaganda. To an impartial view none of our systems A, B and C can be said to possess any outstanding superiority as a matter purely of notation, but, such as there is, seems to rest with B and C rather than with A. In B and C the minimum clearance is shown at a glance by inspection of one dimension. The whole tolerance on each part is also shown as the difference of two dimensions, and this is, as a rule, more convenient than in the system A, where one of the tolerances is derived from the arithmetical sum of a positive and a negative quantity. It may be urged by some that system A indicates more directly the mean fit. In this connection reference should be made to articles by Stoney and Lees and by the present writer in this journal, on March 21, 1919, and June 13, 1919, respectively; in these articles it is suggested that the mean fit is not so simple as it may appear. A far more important matter than the mean fit is the extreme fits which may occur, and these are shown more clearly by systems B and C.

As regards manufacture, much has been said, especially in connection with rimers. The most that can be argued against B is that existing rimers will have about one-half as long a life as under system A for which most of them have been designed. System C would be almost useless for existing rimers. It must be admitted that this reduction in the virtual life of the existing stock of rimers will be a source of expense to some firms, but in many cases this will be more than neutralised by the saving in gauges. It should be noted that the change from A to B is a safe change in that no rimer suitable for A could spoil work dimensioned under system B. In respect of gauging, system A is at a disadvantage as compared with B and C, for in the ordinary procedure of "go" and "not-go" gauges, which has proved so satisfactory under the rigorous test of war-time conditions, system A requires four gauges, none of which is of standard size, while B and C each have one limiting size standard, viz., the nominal. If ring gauges are dispensed with for the shafts our argument is little affected; we have then two plug gauges to reckon with, and in B and C one of these is a standard plug, in A, neither.

More important in this subject than either notation or manufacture is use. If we swap horses will the harness fit, for no doubt A is the horse that most of us have—those of us, that is, who have begun to cross the stream. What is the relative interchangeability of parts made under the two systems A and B? Our diagram makes this easy to discuss. Shafts from B will in almost every case



enter holes from A; when the A holes are worn, a B spare shaft gives a better fit than an A shaft would do. Moreover, all holes from B will fit all shafts from A, and they would give a degree of fit equivalent to an A pair with the hole worn to nominal diameter or more. In short, the average fit produced by using a B hole or an A shaft is not worse than the worst fit under the A system, and such combinations would be very rare, and they would only occur during the transition periods of such firms as have already used system A on a large scale.

System C has been included on our diagram for two reasons. In the first place because the British Engineering Standards Association Sub-Committee on Screw Threads has adopted it (unfortunately, as we believe) in their report No. 84 (B.S.F. Threads), and secondly because some years ago it was favoured by the electrical industry on account of the fact that bright cold-drawn shafting had been newly introduced and very eagerly taken up. Times change, and bright drawn shafting is no longer rated so highly, but this incident is an illustration of the dangerous facility with which standards may be advocated for reasons which though relevant at the time, are really transient; it shows the necessity for caution in deciding the present question of the hole and shaft basis. The crux of the tolerance question in its present phase seems to lie in the issue between fundamental geometrical convenience for all in the future, and manufacturing convenience for some in standardising a system which is not yet widely spread.

Lastly, a suggestion may be offered to the committee who are examining this question and who will receive the replies of the various firms to whom the circular has been sent. We would advocate some form of proportional representation in reducing the results. If a reply is weighted in proportion to the share capital or output of the firm concerned, a more rational measure of the views of industry will be obtained than with the democratic system of one firm one vote. We do not suppose or suggest that the experts in large firms have in all cases a better knowledge and judgment of the matter than those in smaller organisations, but the big firms have more at stake, and the effect of their co-operation or antipathy would be of greater importance. Small firms on the other hand have less to lose by changes and their inertia or alacrity would scarcely affect the question at issue or the ends in view.

HELL GATE BRIDGE, NEW YORK.

By FRANK W. SKINNER, M.Am.Soc.C.E.

(*Continued from page* 418.)

ALL of the steelwork was shipped from the bridge shops by rail, intermediately stored in the Pennsylvania Railroad terminal freight yard at Greenville, N.J., and thence delivered to the site on car floats towed to pile wharves on both sides of the river or held in midstream while the arch members were lifted from them by the erection travellers located on the cantilever arms. It is interesting to note that the floats were more easily handled by their tugs when the tide was strong than in slack water, the obvious reason being that the strong resistance produced by the swift current maintained a more even balance with the powerful tugs. The tide of 10 knots an hour was sufficient to tax the ability of an ordinary steamer, but the floats were usually towed by a single tug which was more easily controlled than when a second tug was sometimes provided.

The material for the main arch was not stored at the site in any considerable quantity and the 160-ton pieces of the lower chords were unloaded from the floats at the Long Island end of the span by a 65-ton stiff leg stationary derrick which lifted one end of the chord and swung it around and lowered it to bearing on a service car while the other end pivoted on the original shipping car. This car transferred the piece about 100 ft. until it was received by the hoisting tackle of the erection traveller and lifted bodily to position.

On Ward's Island steel was unloaded from the float by a similar derrick that deposited it on two cars that transferred it to a position opposite the abutment, whence it was pulled 50 ft. transversely on greased skids by an anchored tackle that hauled it into position where it could be handled by the erection traveller.

ERECTION OF BACKSTAY SYSTEMS.

Erection operations were commenced by the building of the backstay trusses (see Figs. 41 and 43, on Plate XXI, published with our issue of September 26th) after the contractor's general equipment had been installed and electric power provided for operating the derricks, travellers and air compressors. Alternating current with a voltage of 7,200 to 8,200 and an amperage of 40 to 55 was purchased from a commercial company and transformed at the bridge site into direct currents of 550 volts to 600 volts and 50 amperes to 900 amperes, by a three-phase 60-cycle generator set with a capacity of about 500 h.p. The electric power operated all of the hoisting apparatus and two air compressors, each driven by a 75-h.p. motor with a capacity of 225 cub. ft. of free air per minute, to a receiver, the working pressure was 135 lb. per square inch. Erection diagrams were made of the assembled backstay trusses, and all the successive operations were carefully detailed on them with explicit instructions.

The stiff-leg derricks on the wharves were erected by the lighter derricks, and the wharves were connected with the anchorages by locomotive cranes running on trestles 25 ft. high. The surface of the ground was graded uniformly, and the lower chords of the backstay trusses were assembled in position by the locomotive cranes. The locomotive cranes then assembled six stiff-leg derricks that handled the material for the counterweights (Fig. 44, on Plate XXI). The counterweight derricks then erected the bottom tier of counterweight girders, and on them erected the backstay travellers.

The backstay travellers (Fig. 42, on Plate XXI), which were also designed for subsequent use in erection of the viaduct approach spans, had a capacity sufficient to handle the 35-ton plate girders that formed units in the backstay members. The travellers were constructed of steel throughout with a horizontal platform supported at the rear on vertical posts maintaining it in a horizontal position when the forward end of the platform was supported on the inclined top chords of the backstay

HELL GATE BRIDGE, NEW YORK.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

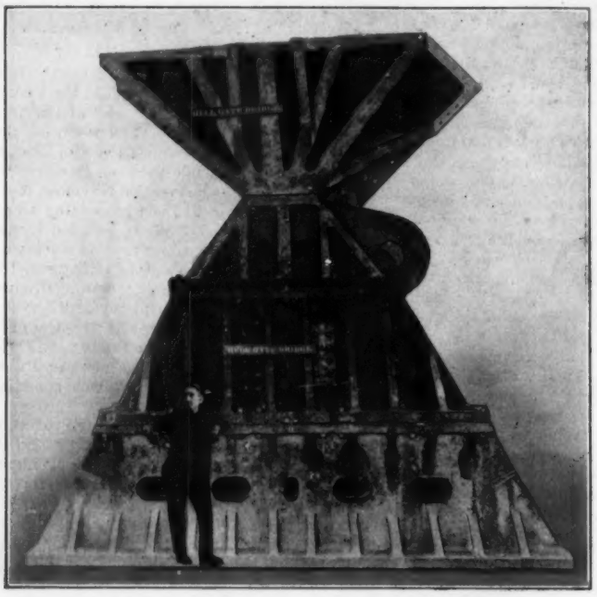


Fig. 45. Side View of Cast Steel Pedestal.

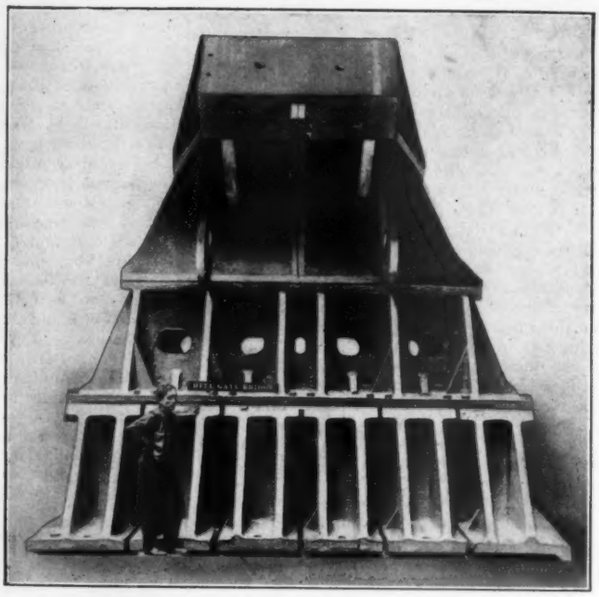


Fig. 46. Front View of Cast Steel Pedestal.

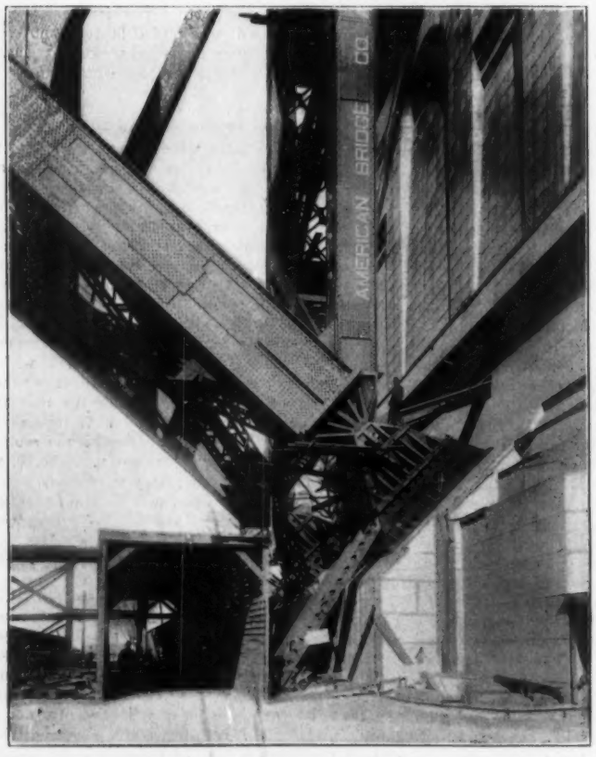


Fig. 47. Detail showing Temporary Anchorage of Skewback Bearings to Pier.

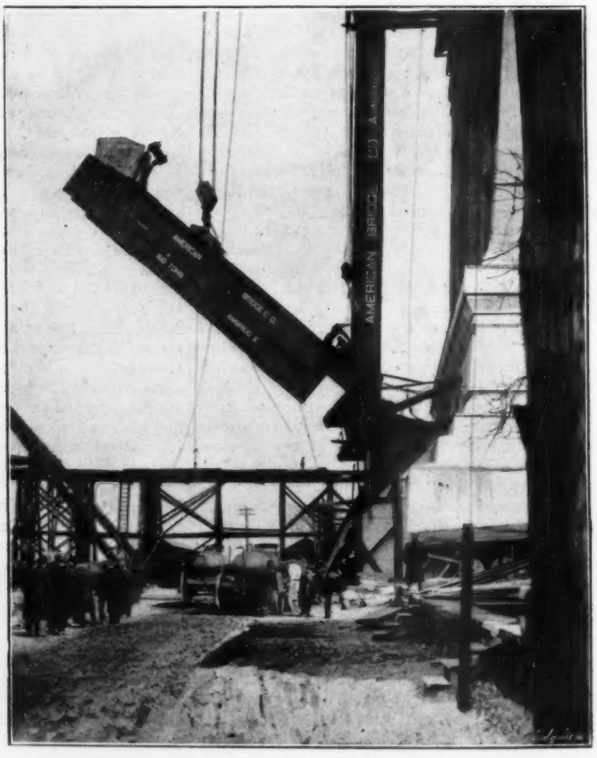


Fig. 48. Erecting First Section of Bottom Chord, Total Weight about 180 Tons.

trusses. The platform carried a vertical A-frame equipped with a 110-ft. boom having a capacity of 35 tons at 100-ft. radius. The traveller platform was 60 ft. wide, enabling it to be supported on both trusses of the backstay.

After the completion of the backstay traveller it erected the backstays up to the point of intersection of the front and rear portions of the backstay top chords, after which it erected the arch traveller on the horizontal portions of the top chords of the backstays as a platform.

Arch Travellers.

On each side of the river the traveller that had erected the backstay trusses also erected from its position on the top chords of the backstay, the regular arch traveller in its preliminary position on the horizontal portion of the backstay top chord.

This traveller (Figs. 41 and 42, on Plate XXI) had a horizontal plate girder platform about 46 ft. long and 68 ft. wide, with the forward end mounted

with pivot connections to four-wheel trucks running on the top chords of the arch trusses. The rear end of the platform was supported by vertical posts with pivoted connections to similar trucks also running on the top chords of the trusses, but which, on account of the inclined positions of the chords, were always at a lower elevation than the forward trucks and were braced to the platform by diagonal struts which with the verticals were adjustable, permitting their effective length to be varied so as to always maintain the platform in a horizontal plane as it moved along the arch curve.

The platform supported at the forward end an A-frame, 48 ft. high, which was braced by two long stiff-legs to the rear corners of the platform. At the centre of the base of the A-frame there was pivoted the 70-ft. main steel boom, with a capacity of about 200 tons at full radius. The traveller was also equipped with two 60-ft. 15-ton wooden booms, one at each front corner and each having a vertical mast braced by a horizontal transverse strut to the top of the A-frame. There were also two similar but rather smaller booms installed on the rear of the platform for miscellaneous service and to erect light struts in the lateral and transverse bracing in the rear of the traveller.

The main boom topping lift was rove with 36 parts of $\frac{1}{8}$ in. monitor steel plow line, and 32-in. sheaves. The hoisting tackle was rove with 26 parts of a similar steel rope, 7,000 ft. long, with both free ends led to separate four-drum eight-spool 250-h.p. electric hoisting engines, installed at the rear end of the platform where they served as counterweights. The hoisting tackles were so arranged that the outer parts of the lines passed over detachable sheaves and could be readily removed, permitting the number of parts to be quickly reduced without unreaving the line and thus securing more rapid hoists and using less line for light loads than for heavy loads. This arrangement worked well, and was particularly convenient because the first arch members hoisted, namely, the end lower chord pieces which weighed 185 tons each, were the heaviest in the span and were hoisted to the lowest elevation. These pieces were hoisted about 45 ft. while the top chord members at the centre of the arch were hoisted to a height of 305 ft. above the surface of the water. The tackles were connected to the boom and A-frame by pairs of 7-in. eyebars, giving increased clearance for the sheaves, and the boom was swung horizontally by two sets of 9-part $1\frac{1}{2}$-in. manilla rope tackles.

All of the principal arch members were handled by the main boom of the traveller and the arch trusses and connections were so designed that each member became self-supporting as soon as assembled in position, thus making it unnecessary to provide temporary supports for it, while the other members in the same panel were erected. As soon, for instance, as a bottom chord section was assembled and service bolted to the preceding section, it acted temporarily as a cantilever, and the same was true of the diagonal member of the same panel. The two together supported the vertical posts, and the rigidity and panel point connections of the three served to support the forward end of the top chord section until its joints were fitted, and the four principal members of each truss panel acted together completing another panel of the cantilever system and extending the trusses for the advance of the traveller to its next position.

Besides the large hoisting engine each traveller had a two-drum, four-spool 100-h.p. electric engine for operating the small derrick booms, whip lines and other auxiliary services. The traveller was operated by a special crew of men whose best record was the erection of one complete panel of truss and braces in one 8-hour day. The total weight of the traveller and equipment was 315 tons, as compared with about 1,000 tons for the travellers used for erecting the cantilever arms of the main span of the Quebec Bridge. The latter did not have to handle as large heavy pieces as these travellers, but were required to support or partly support several of them until they became self-sustaining, thus greatly increasing the weight of the traveller, which was also much greater on account of the tower type employed which necessitated much longer and heavier members than those of the multi-type for the Hell Gate Bridge. The decreased weight of the Hell Gate travellers was very advantageous and effected considerable economy, as every pound of additional traveller weight required 2 lb. or 3 lb. more of steel members in the backstay and anchorage system.

Fig. 49.

Fig. 50.

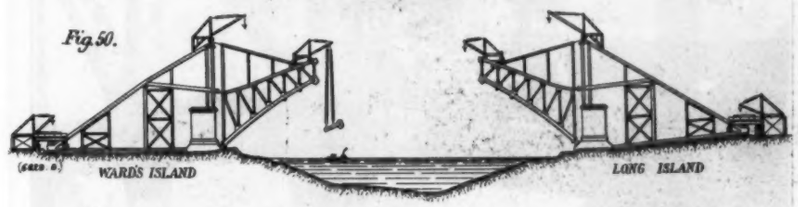


Fig. 53.

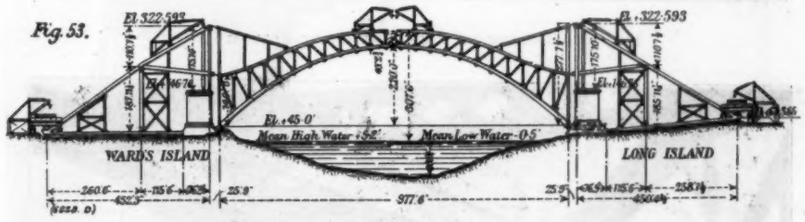
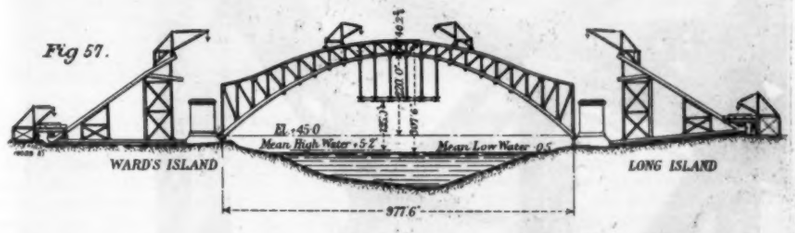


Fig 57.



Erection of Arch Trusses.

It was the original intention to commence erection of the arch truss spans simultaneously on both sides of the river and to build them out equally until they met at mid span, but as the main pier at the Long Island end was ready about eight months before the other pier, work was first commenced there and three panels of the arch trusses were built at this end before erection of the trusses was commenced at the Ward's Island pier.

The first operation in the erection of the arch span was the setting of the 248-ton skewback pedestals (Figs. 45 and 46, on page 500), the pieces of which were handled separately by the main travellers seated on the backstay trusses over the main pier. Great care was taken to set the pedestals (see Fig. 47, on page 500) with extreme accuracy, because any imperfection in their position would cause a greatly magnified displacement of the arch trusses at the crown that it would be particularly difficult to correct in the horizontal plane.

After the pedestals were securely anchored in position the $11\frac{1}{2}$-ft. by $6\frac{1}{2}$-ft. by 50-ft. 185-ton end sections of the lower chords (Fig. 48, on page 500) were erected by the traveller in the same position and supported by tie rods. The hoisting tackle of the traveller being then released, the traveller proceeded to successively erect the remaining members of the first panels of the trusses (Fig. 49) and to connect the land ends of the top chord sections and the tops of the end vertical posts to the horizontal top chords of the backstay trusses by short eyebar links, thus providing anchorage for the cantilever trusses.

The horizontal traveller track was then extended from above the top chord of the backstay trusses to rest on the arch trusses near the second panel point (Fig. 42, on Plate XXI), and the traveller advanced on it and erected the members of the second panels of the arch trusses in the same sequence as was subsequently followed for the erection of the remaining panels to the centre of the arch.

The two bottom chords were raised into position by the traveller having its front truck at the end of the last finished panel. The rear end connection joints were fitted up with bolts and drift pins, the former being used only to draw the plates together, and drift pins being relied upon to transmit all the shearing stresses and to provide for any possible stress developed by wind, temperature or static load sometimes, requiring the whole 100 per cent. efficiency of the connection, and even requiring in some cases the driving of a few extra rivets, more than were computed to be necessary for the ultimate stresses in the finished bridge. With this exception the riveting of the field connections of the truss members was not done until after the erection was completed and the trusses were swung when the joints transmitted full dead-load stress.

After the completion of the bottom chord connections the hoisting tackle was released, the diagonals hoisted and connected at both ends, the laterals assembled between the bottom chords, the vertical posts and top chords and sway bracing pieces following successively one member at a time.

Nearly all the steel was raised from lighters in the river and the chord sections which were to meet transportation requirements shipped from the bridge shop separate from their large gusset plates were fitted up on the barges, and the gusset plates assembled to them increasing their weight considerably above the shipping weight. All of them were handled by clevis connections to pairs of special hoisting angles riveted to the pieces and afterwards cut off and the rivet holes filled with permanent rivets. Care was taken to locate and arrange the temporary hitches so that the pieces were hoisted in position parallel to their permanent location, thus avoiding the necessity of materially

tipping or swerving them by hand lines and eliminating the necessity of auxiliary tackles for adjusting them. The first panel on the Long Island side was erected in about three weeks, after which the time required for each panel decreased as the men became familiar with their work, and the weight of the pieces handled diminished until the tenth panel on the Ward's Island side was completely erected in 7½ hours. After the completion of each panel the traveller was hauled forward on the top chord by anchored tackles operated by its hoisting engine, and was clamped and blocked in position until ready for the next movement. About 1 hour was required for shifting the traveller from one position to the next, and about the same time was required for making connections to one of the large chord members, hoisting it to position, securing it there, and releasing the traveller hoist.

The handwork required for entering the members in their field connections and assembling them, and fitting up with service bolts and drift pins, was facilitated by the provision of suspended working platforms for the erectors. These platforms, which were shifted from panel to panel as the traveller advanced, were handled by the small booms on the forward end of the traveller and were suspended just below the bottom chord transverse to the bridge axis. Each of them consisted of a standard Pennsylvania railroad signal bridge made with two light lattice girders more than 60 ft. long, carrying a working platform and hand rail. Smaller platforms and steel cages were suspended from above to enable the men to work as required on other parts of the trusses, and both the large and small platforms were used by the riveting gangs after the erection was completed.

After the erection of the first six panels of the bridge (see Fig. 50, on page 501, and Fig. 51, on Plate XXX), at each end the stresses developed in the backstay trusses strained the top chords of the latter nearly to their proper limit, and the strains would have been more than doubled if the erection had been continued with the same backstay arrangement. Therefore, in order to reduce the stresses, maintain them within the limit of the sectional area of the backstay members available and to increase the stability and rigidity of the structure the backstay towers were extended to a height of 175 ft. 10 in. above the top of the unfinished masonry pier (Fig. 52), and the inclined tops of the backstays were continued in the same line to intersect them at the upper ends where they were supported on saddle castings, each of them seated on a special 3,000-ton hydraulic jack on top of the tower. The saddles were pin-connected to the new river ends of the backstay truss top chords that descended from this point to intersect with the top chords of the arch trusses at the fifth panel point where they were connected by eyebar links.

After these connections were made the hydraulic jacks were operated to adjust the backstay trusses until the lower top chord sections were relieved and all the stress was taken through the new top chords, thus entirely releasing the old horizontal sections, which were removed, and the remainder of the arch truss erection from the fifth panel points to the crown was carried out as a cantilever projecting beyond the ends of the backstay top chords.

Although the arch truss members were assembled, riveted and finished with the utmost care and accuracy, and although the rivet holes drilled in position when the members were temporarily assembled at the bridge shop yards were at that time perfect, it was found that when the work was again assembled in the field some of the different thicknesses of metal in the heavy members had crept more than others, causing an overlapping of the plates pierced by the same rivet hole of as much as ⅛ in. A similar phenomenon had been observed on previous work by the same contractor, but was never as marked as on this work, which was so much heavier than any precedent.

Span Measurements.

As no previous structure crossed the river at the side of this bridge it was impossible to secure a satisfactory direct measurement and the distance between skewbacks was determined by the chief engineer by triangulation. In order to check this the bridge company had a special tape made about 1,100 ft. long and took repeated measurements with it, making calculated allowances for tension, deflection, and temperature, but found considerable difficulty in making the corrected measurements precisely agree on account of the unequal temperatures of different portions of the long steel tape. These measurements, however, indicated substantial agreement with the triangulation measurements, and when all but the last three panels of the trusses had been erected the distance between the ends of the chord pieces were checked by a long tape which verified the previously determined length.

The day before the erection of the last panel of the arch trusses (Fig. 53, on page 501, and Fig. 54 on Plate XXX) was commenced careful measurements showed a clearance of

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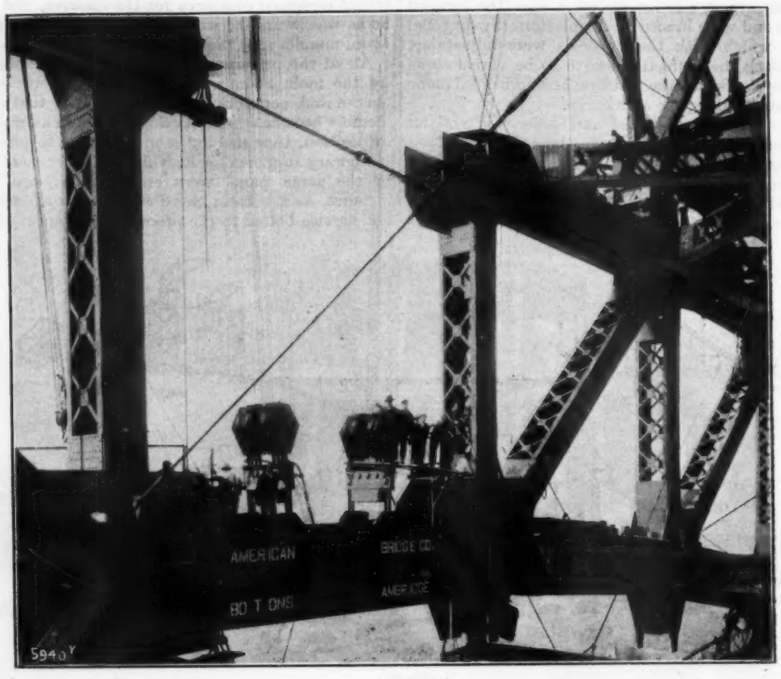

Fig. 55. Assembling East Section of Bottom Chord.

Fig. 56. Centre Panel of Arch Trusses.

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MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

Fig. 59. Floor Beams Suspended from Arch Trusses.

1¾ in. between the extremities of the semi-trusses. During the following night the temperature rose considerably, so that in the morning the clearance was diminished to ¾ in. Work was, therefore, hastened to enable the lower chords, Fig. 55, to be erected before the temperature rose enough to eliminate all the small clearance remaining. The lower chord pieces about 42 ft. long weighed 80 tons each and the first one was successfully connected up in place about 11 o'clock in the morning when the increasing heat had diminished the clearance so much that the piece had to be lifted vertically into position rather than revolved from an oblique position in a vertical plane as is customary. The erection of the second and last lower chord piece was commenced about 11 o'clock when the very heavy tide running up stream made the river navigation very heavy. The next day was rainy and cloudy, affording more favourable weather conditions. After all the drift pins were driven through the joint holes, at about 1.15 p.m. the adjustment jacks in the top of the pier towers were operated and gradually lowered the backstays, and with them the crown of the arch until all of the stress was taken up by the lower chords of the arch trusses, and the backstay jacks having been lowered 22 in. in an hour and a quarter were entirely released, so that the incompleted trusses formed a three-hinge arch that was self-sustaining, permitting the subsequent removal of the backstays.

Bottom chord joint L-22 then became the temporary crown hinge of the arch and the top chord sections 23-23, Fig. 56, and the two remaining diagonal members were connected at one end only. The arch travellers were then moved back from the crown of the arch to panel point 11 where the top chords were connected with the backstays and the travellers commenced the removal of the latter after which they returned to the crown erecting the floor suspenders and floor beams (see Fig. 57 on page 501, and Figs. 58 and 59 on Plate XXX). Meantime the backstay travellers which had remained on the top chords of the backstay trusses near the main piers continued the removal of the backstay trusses and the arch travellers returning from the crown to the skewbacks completed the erection of the suspended floor.

After the backstay trusses had been removed by the backstay travellers moving on their top chords from the piers to the anchorages the travellers removed the anchorage girders and were themselves taken down by the same derricks with which they were originally erected. The locomotive cranes then removed the lower chords of the backstay trusses releasing the stringers of which they had been composed for erection in the permanent floor of the arch spans. They were delivered by the locomotive cranes to barges, towed under the span, hoisted to place and erected by the arch travellers moving from the centre to the ends of the span after which they themselves were dismantled by derricks set up on the nearly horizontal top chords of the end panels of the span.

Up to this point the two semi-trusses were connected only through their bottom chords. The top chord and one diagonal member in the centre panel being fixed at one end and loose at the other end and thus free to slide and permit distortions from variations of temperature. The lower chord being comparatively flexible at the crown joint made the span virtually a three-hinge arch which was then transformed to a two-hinge arch by solidly riveting the remaining connections in the centre panel and bringing the truss action into play at this point (see Figs. 54 and 56). Afterwards the driving of the field rivets in the arch trusses, the placing of concrete the floor, ballast and track laying completed the span.

Connecting Semi-arch Truss Lower Chords.

The centre panel of each arch truss is composed of one lower chord member L22-L22, one top chord member U23-U23, one diagonal U-23, L-22 and one semi-diagonal M-23, L-22, and one semi-diagonal U23-M23. When the bottom chord pieces L-22, L22 were erected the travellers stood with their front trucks at panel points U-21 on both the east and west sides of the centre. These details will be clear on reference to Fig. 33 on page 296 *ante*.

The ends of the lower chords at L-22 were about 15 in. higher than their required final positions in the completed structure and varied about 6 in. in elevation and about 1 in. horizontally from the required position in vertical planes.

The distance L22-L22 between the lower chords of the cantilever arms of the south truss was about 4½ in. longer than the length of the centre chord section L22-L22, that as shipped weighed 80 tons (Fig. 55), but with the enormous gusset plates added weighed about 85 tons as hoisted by the tackle of one of the travellers which by this time had been reduced to 17 parts. The gussets, 17 ft. 4 in. wide, being beyond the capacity of the rolling mills were in this case made with two pieces meeting on the vertical line of the joint. The splice plates already riveted to the ends of the erected bottom chords were spread to permit the projecting gusset plates to enter between them as the top chord section was hoisted vertically to position. As soon as the field rivet holes at the east end of the chords registered in both the splice plates and the gusset plates they were filled with drift pins and bolts, supporting the centre panel member and releasing the traveller falls, while the other end of the chords remained substantially free except for friction with the splice plates on the west cantilever arm. The diagonal, Fig. 56, was then erected and connected at the upper or east end, half of the opposite diagonal was erected and fastened at the lower end and at the centre of the panel. The same operations were performed for the north truss thus completing on September 30, 1915, the erection of all members of the arch trusses except the centre panel, top chords, and the upper half of one of the centre panel diagonals in each truss. On the following day the backstays were slacked off until the lower chord sections took bearing in the open joint L-22 on the west side of the centre, transforming the two cantilever trusses to three-hinge arch trusses and entirely releasing the backstays which were then removed as already stated.

Lowering and Releasing Backstays.

The lowering and releasing of the backstays was a very critical and delicate operation on account of the changes of deflection and stresses involved and of the large and unequal settlements to be anticipated in the anchorages on account of the transfer of the counterweight loads from the backstay trusses to their supports on ground of different character at opposite ends of the span. It was accomplished by slacking off the enormous hydraulic jacks on the tops of the temporary backstay towers over the main piers in accordance with elaborate calculations and deflection diagrams prepared for the purpose. The work was executed with such skill and precision that the different positions of the structure and the most accurate measurements corresponded very closely with the preliminary

computations, proving both their correctness and the accuracy of the shop and field work.

Under erection conditions the ends of the cantilever trusses were subject to maximum deflections of 20·6 in. on one side and 26·6 in. on the other side due to dead load, weight of traveller, and stretching of the backstays. They were also subject to maximum horizontal displacements of 7·6 in. and 8·1 in. The normal temperature being assumed to be 60 deg., the rise of temperature to 30 deg. above normal (which was nearly experienced in the actual erection) would have moved the ends of the chord pieces far enough out to produce an overlap of 19 in. with the centre chord section while a fall of 30 deg. below the normal temperature would have extended the distance much beyond the length of the centre chord pieces. Therefore by reducing the length of their eye bar links about 12 in. the top chords of the backstay trusses were shortened sufficiently to raise the ends of the cantilevers enough to give a clearance of 1½ in. between the ends of the trusses at a temperature 30 deg. above normal and 8·1 in. at a temperature of 30 deg. below normal.

(To be continued.)

AIR FLOW OVER THE DECK OF THE BATTLESHIP "PENNSYLVANIA."

In January of last year some experiments were made by the United States Navy Department on a model of the battleship Pennsylvania, in order to determine suitable aerodynamical and structural conditions for the landing of light aeroplanes on the after deck of the vessel. The experiments, which are described by Dr. A. F. Zahm in a recent issue of the *Journal of the Franklin Institute*, were made in the 8 ft. square section wind tunnel of the Department, on a $\frac{1}{48}$th scale model, at a wind speed of 30 m.p.h. The full-size vessel has a length of 600 ft., a beam of 97 ft., and the after deck is 25 ft. above the water level. There are two triple gun turrets on the after deck placed on the centre line of the vessel—one firing over the other.

To investigate the air flow the model, in its normal condition, was first placed on the floor of the tunnel, midway between the sides, and measurements of the wind velocity in the vicinity of the stern were made by means of a pitot tube. The latter was placed at numerous points within a region extending, in the full-size ship, from 60 ft. forward of the stern to 40 ft. aft of the stern, at heights of 5 ft., 15 ft. and 25 ft. above the level of the deck. In the centre line of the ship the velocities measured in the lowest plane ranged from 9·9 m.p.h. to 12·2 m.p.h., in the intermediate plane from 13·3 m.p.h. to 14·6 m.p.h., and in the upper plane from 14·9 m.p.h. to 16·5 m.p.h., the velocity of the main flow in the tunnel being 30 m.p.h. in all cases. In a vertical plane 24 ft. on the port side of the centre line considerably higher velocities were obtained, the figures being 19·1 m.p.h. to 20·4 m.p.h. for the lowest plane, 22·4 m.p.h. to 24·6 m.p.h. for the intermediate plane, and 25·1 m.p.h. to 25·7 m.p.h. for the uppermost plane. The flow was next examined visually and photographically by means of short silk threads attached to thin steel wires, and the results obtained from these experiments, as well as from the pitot tube readings, show a marked interruption of the air flow near the deck, due mainly to eddies caused by the rear gun turret. It was therefore concluded that difficulty would be experienced in landing an aeroplane on the deck of the ship in its unaltered condition.

A shelf deck was then fitted on the model at a height of 5 ft. (in the full-size ship) above the main deck, and extending from a point just under the guns of the rear turret to the stern of the ship. In the full-size ship this deck would measure 80 ft. wide by 120 ft. long. Another deck extending from the mast to the stern above both turrets was also tried. This larger deck would measure 100 ft. by 180 ft. on the full-size ship and its height above the main deck would be 25 ft. Methods similar to those outlined above were used to investigate the air flow over these decks, but the wind speed used in the tunnel was only 20 m.p.h. In the case of the smaller deck, minor disturbances in the air flow were detected at a height of 15 ft. above the main deck, and these disturbances were attributed to irregular flow round the hull. With the larger deck only a slight tendency of the air to spill over the edges was noticed. In both cases it was considered that the width of uniform air flow would be ample for the safe landing of small aircraft.

In a subsequent test the stream lines were mapped out for the larger deck in the plane of symmetry of the vessel and also in a plane half-way between the centre and the edge of the deck on the port side. The wind speed used for this test was 30 m.p.h., and the planes investigated extended for a height of 56 ft. above the deck. The lower stream lines in the plane of symmetry appear to rise slightly from the forward edge of the shelf deck and bend down again towards the after edge, whereas the upper stream lines have a slight downward tendency in the forward part and then become practically parallel with the deck. In the lateral plane investigated the stream lines are almost exactly parallel with the deck for the whole of their lengths. This seems to indicate that an aeroplane would fly steadily in the plane of symmetry of the ship, but would have a tendency to unsteadiness when flying on either side of this plane.

In connection with the above experiments it would be interesting to know if the conclusions arrived at were confirmed by experience with the full-size ship. It must be pointed out that the unavoidably small scale of the model, and the rather low wind speed used, give a very small value for vl. True dynamical similarity is only obtained when the product vl for the model is the same as that for the full-size ship, so that the $\frac{1}{48}$th scale model tested at 30 m.p.h. would correspond to a wind speed for the ship of only $\frac{5}{8}$ mile per hour; the air flow would probably be very different at higher speeds. It is also questionable whether the silk threads give an accurate indication of the direction and nature of the air flow. To some extent their indications would be affected by the weight of and the tension in the threads, and also, perhaps, by the presence of the steel wires to which they are attached. Probably the most reliable instrument for mapping the air flow near a model is the yawhead illustrated and described on page 364 of our last volume, though the use of this instrument is somewhat tedious. It would certainly be of great assistance in such investigations if some optical method could be devised to enable the motion of the air in any particular plane to be seen and photographed without the introduction of any object which would itself disturb the flow. The sound waves in air set up by the motion of a rifle bullet have been photographed, so that it may not be impossible to render the smaller disturbances visible.

THE SHIPPING AND MACHINERY EXHIBITION AT OLYMPIA.

(Concluded from page 480.)

There are a number of interesting appliances and machines at the Olympia Exhibition which we were not able to deal with in our previous issues, and of some of these we propose to give a description in this—our concluding article. As before, we do not propose to follow any obviously logical order in our arrangement of the subjects dealt with, particularly as a number of them involve large illustrations and the descriptive matter necessarily has to follow the arrangement of these illustrations on our pages.

We may begin with the display of control gear which is made by Messrs. Allen West & Co., Limited, of Lewes Road, Brighton. Messrs. Allen West have from the first made a point of robust and sound construction in their gear and have not, we think, at any time competed for a very cheap market. The material shown at Olympia is of a good class and in accordance with the firm's reputation. We illustrate in Fig. 36 to 39 on page 505 some examples of the type of contactor gear which is shown. Fig. 38 illustrates the firm's standard contactor. This, of course, is subject to various modifications, or rather additions, as it may be required for various services. No cast-iron whatever is used in its construction, and the magnetic circuit is composed entirely of high quality mild steel. This ensures a very lively and quick operating switch. A pair of these contactors arranged with mechanical and electrical interlocks is shown in Fig. 37. The interlocks ensure that only one contactor can be closed at a time. Such an arrangement would be used, for example, in connection with a contactor gear controlling a reversing motor; the closing of one or other of the contactors representing the starting of the motor in one or other direction. The mechanical interlock is simple and effective. It consists of two pivoted quadrants connected by links to moving parts of the contactors. The quadrants are arranged so that one fouls the other when either contactor is closed, so preventing the other from closing. The electrical interlock contacts are worth mention. As will be seen they consist of a pair substantial mechanically hinged fingers with the pressure applied by a spiral spring. A good wiping action is obtained each time a contactor closes so that the contactors are self cleaning.

A third detail of the gear is illustrated in Fig. 39. This is the overload time limit relay which is, of course, employed in various applications. The thermal time lag is of interest. This device has the merit of great simplicity as compared with almost any type of dash-pot arrangement. It also has no moving parts. An obvious criticism of any device of this kind is that its operation will be some function of the room temperature, but Messrs. Allen West advise us that any variation in the conditions of operation which may be induced by variations in the room temperature are outside the limits of practical importance. The device hardly needs any description. It consists merely of a shunt across the main coil of the relay and arranged well in front, as shown in the figure. The metal of the shunt has a negative temperature coefficient, so that when overload comes on the shunt heats up, and as its resistance rises, more current flows through the main coil and so operates the relay. This relay can be wound with a shunt coil and act also as a no-volt device.

Our remaining illustration, Fig. 36, shows the connections of a five point reversing contactor panel with a five point master controller, limit switches and series brake for use with a direct current series motor. It illustrates an application of the contactors we have dealt with above. The greater part of the arrangement may be followed from the diagram, but the lock-out coils on the contactors should be mentioned, and we have not referred to them above. These are fixed on the board one below each of the resistance-cutting-out contactors and serve to control the order of closing. These coils hold each contactor in the open position until the one immediately preceding it has closed. Considering, for instance, contactors VI and VII, it will be seen that as long as VI is open the lock-out coil of VII carries the full series current, so that the contactor is held securely open. The closing of VI, however, cuts out half of the lock-out coil of VII, so that when the closing coil is energised it is able to overcome the lock-out coil and close VII in turn. If, however, the master controller is worked too rapidly and the closing coil of VII is energised before VI is closed, it will be unable to close VII as its lock-out coil would then be carrying the full series current.

The stand of Messrs. Hadfield's, Limited, of East Hecla and Hecla Works, Sheffield, is well worthy of careful inspection, but the nature of the exhibits does not lend itself to descriptive writing. We noticed a number of "Hecla" steel forgings including a crank pin and other parts of a marine engine, a disc 5 ft. in diameter for a steam turbine, and two eccentric shafts for a stone breaker. A marine shaft forging, which had been fired at by projectiles in order to demonstrate its toughness, is also on view. Various objects made of the firm's well-known "Era" manganese steel, which has an extremely high resistance to abrasion, are included in the exhibit. Of these we may mention component parts of dredgers and crushing machines, and also tramway points and crossings. A tramway crossing and rail taken up from Fitzalan Square, Sheffield, where the traffic is exceptionally heavy, after twelve years' service, is shown, and this forms a remarkable testimonial to the wearing properties of

EXHIBITS AT THE SHIPPING AND ENGINEERING EXHIBITION AT OLYMPIA.

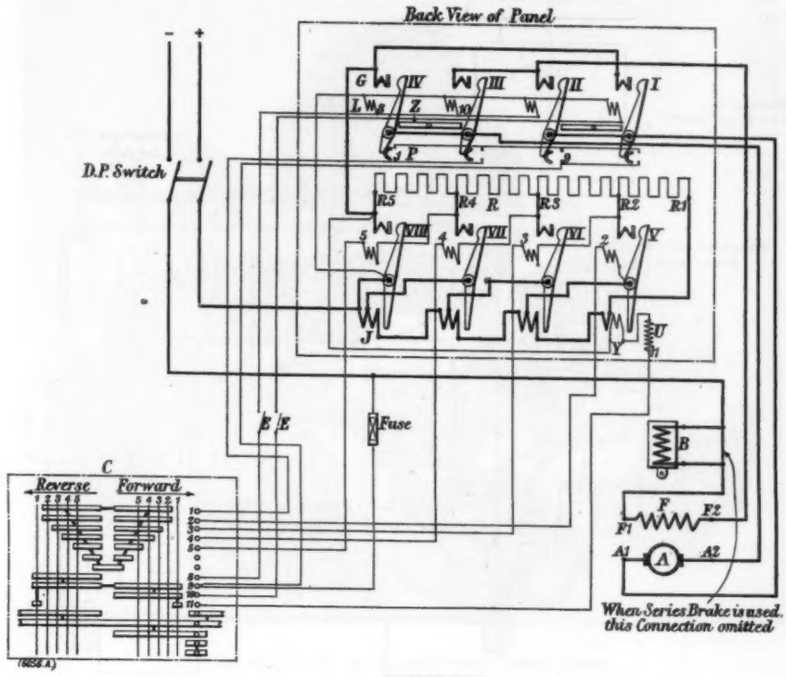


Fig. 36

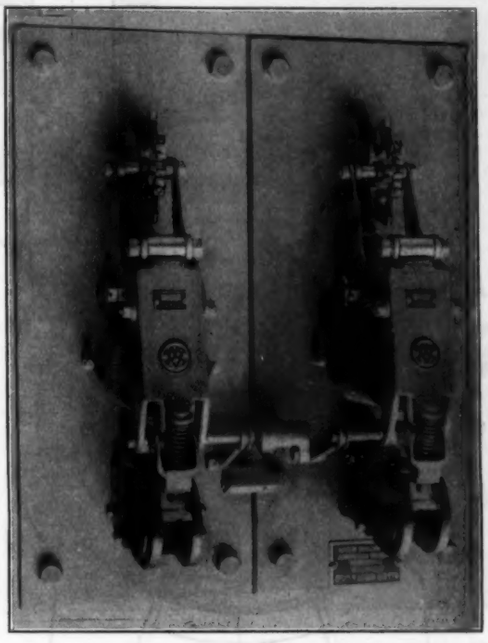


Fig. 37.

I to VIII = Contactors. Order of Closing, II and IV, or I and III, V, VI, VII, VIII.

Index to Reference Letters—A = Armature. B = Series brake. C = Master controller. E = Limit switches. F = Series field. G = Blow-out coil. J = Lock-out coil. L = Operating coil. P = Interlocking contacts. R = Series resistance. U = Resistance Unit. Y = Shunt lock-out coil. Z = Mechanical interlocks.

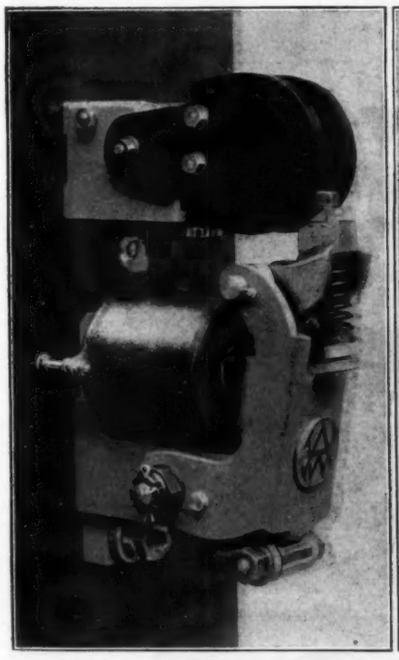


Fig. 38.

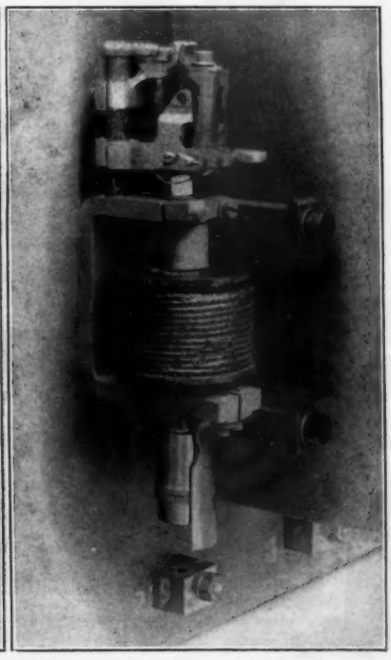


Fig. 39.

Figs. 36 to 39. Electric Motor Control Gear; Messrs. Allen West and Co., Ltd., Brighton.

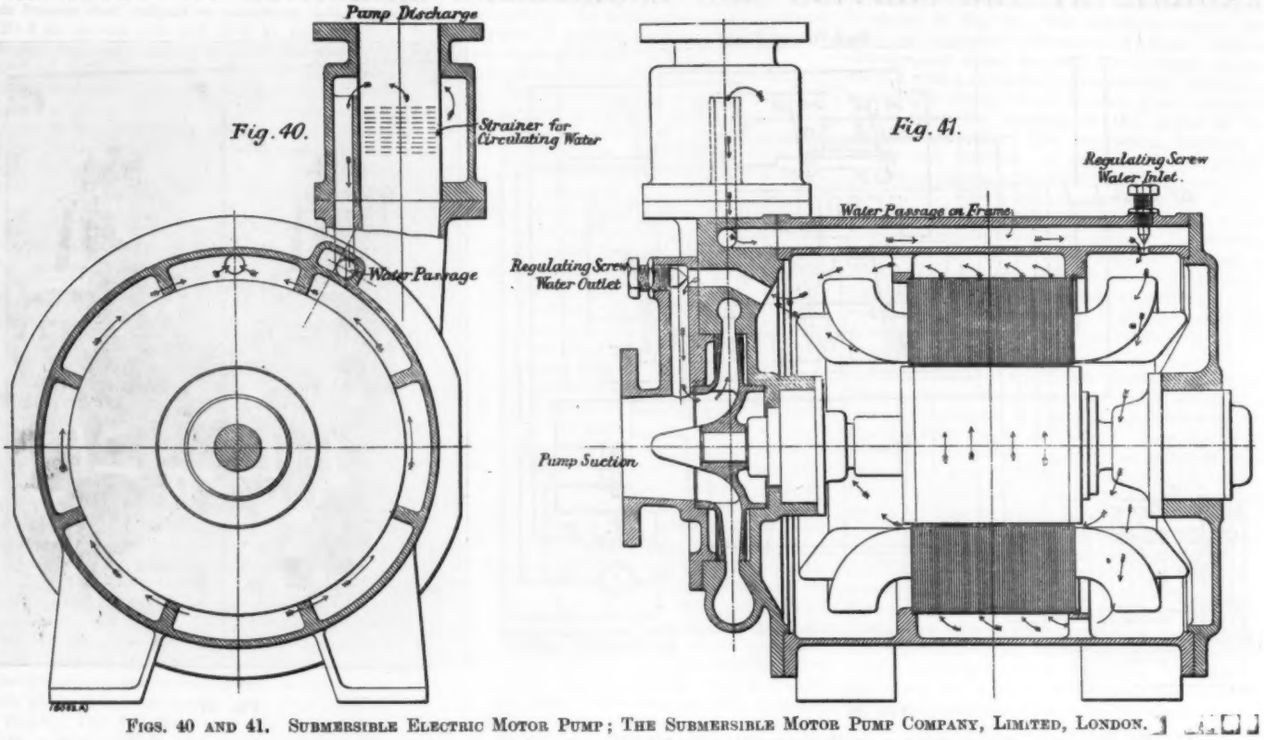
the steel. The track at the above-mentioned place has recently been entirely re-laid with Messrs. Hadfield's "Era" steel rails, and the nature of the work is illustrated by means of a model included in the firm's exhibit. Other noticeable items shown include locomotive wheel centres, and other parts, in toughened cast-steel, cold rolls, an ammunition tube in "Era" steel weighing over 12 tons, an 18-in. armour piercing projectile, a 6-in. trench howitzer, and test bars of "Hecla" and "Era" steels for aircraft and motor-car manufacture. A Guillery shock testing machine is also in use on the stand for demonstrating the qualities of the firm's products.

An interesting exhibit has been staged by Messrs. Submersible Motors, Limited, of Johnson-street, Southall, Middlesex. This consists of examples of their submersible motor pump, salvage generating sets, rotary transformers for converting ships' direct-current supply to alternating current for submersible motor pumps, salvage switch gear and other details. The essential feature of interest on the stall is, of course, the submersible motor pump which is the speciality of the company. We described this pump in its early form in our issue of March 10, 1911. Since then it has made much progress. The pump had reached something like its present form when the war started, and has proved of great value in connection with the large amount of ship salvage work which has followed on the operations of the war. We understand that during the past four years more than 600 submersible motor pumps have been supplied to the British Admiralty, and the French, American and Japanese Navies.

The essentially important feature of the submersible motor pump is that its motor end is so constructed that it can work fully immersed in water. The motor is not made watertight, and depends in no way on watertight casings; but, on the contrary, the water has full access to its interior and circulates round the windings and between the rotor and stator. An end view and cross-section of a characteristic motor pump are shown in Figs. 40 and 41, on page 506. The cross-section shows by arrows the path of the water through the motor. It will be seen that a by-pass is taken from the far side of the strainer in the discharge, and that water is led from this through a passage to the far end of the motor. This water ultimately discharges into the pump suction as shown. The arrangement has the obvious advantage that the windings are very adequately cooled quite apart from the fact that the motor is rendered indifferent to its working conditions from the point of view of moisture. The motor is 220 volts three-phase, with a short-circuited rotor, and all insulation is, of course, water resisting.

As will be clear from Figs. 40 and 41, the motor pump forms a self-contained unit which can be lowered into the hold of a sunken ship. All that is necessary in the way of connections to it are the connecting up of the power leads and the discharge pipe. Special generating sets for supplying power to these motor pumps have been constructed and an example, with an engine by Messrs. W. H. Allen, Son and Co., Limited, of Bedford, is shown in

EXHIBITS AT THE SHIPPING AND ENGINEERING EXHIBITION AT OLYMPIA.



Figs. 40 and 41. Submersible Electric Motor Pump; The Submersible Motor Pump Company, Limited, London.

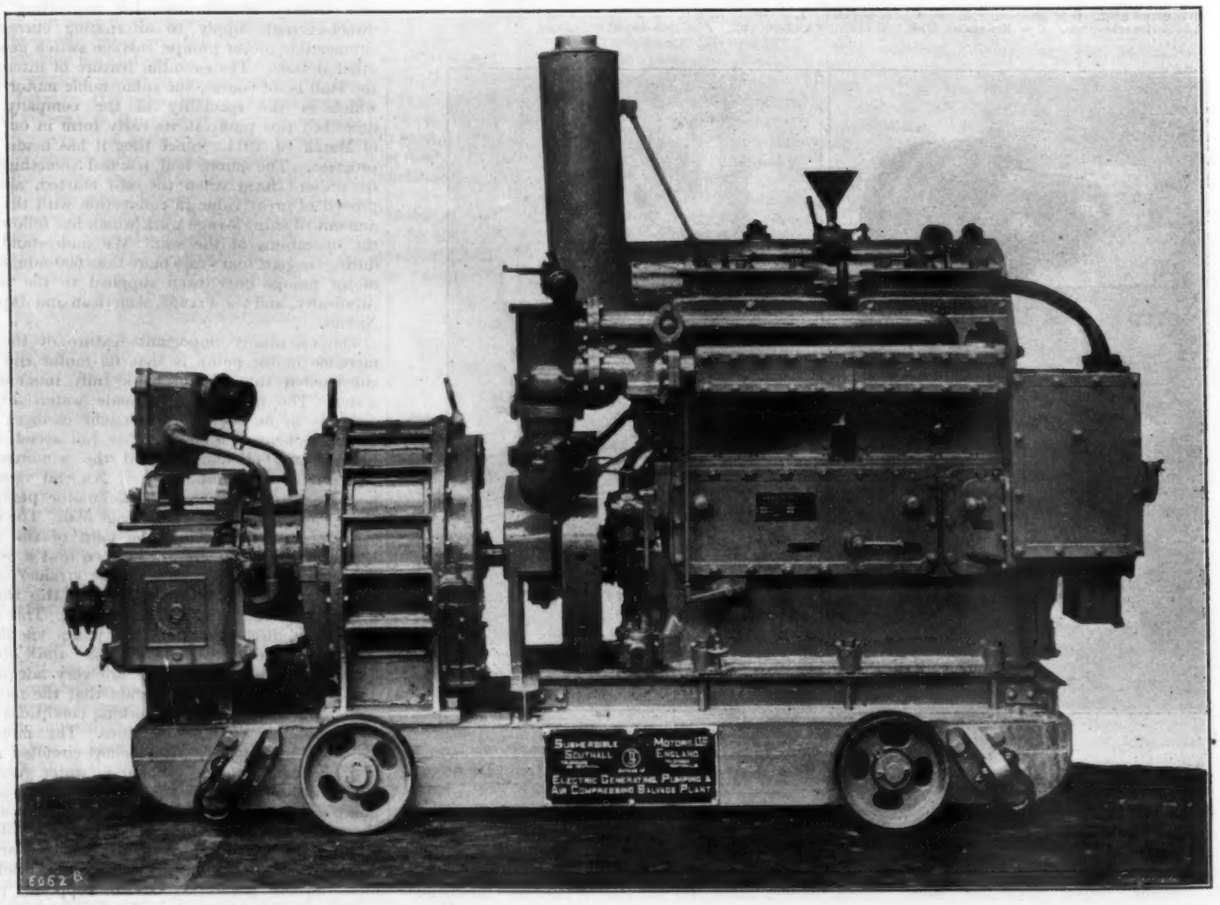


Fig. 42. Weatherproof Pumping-Set Driven by Engine; Messrs. W. H. Allen, Son, and Co., Limited, Bedford

EXHIBITS AT THE SHIPPING AND ENGINEERING EXHIBITION AT OLYMPIA.

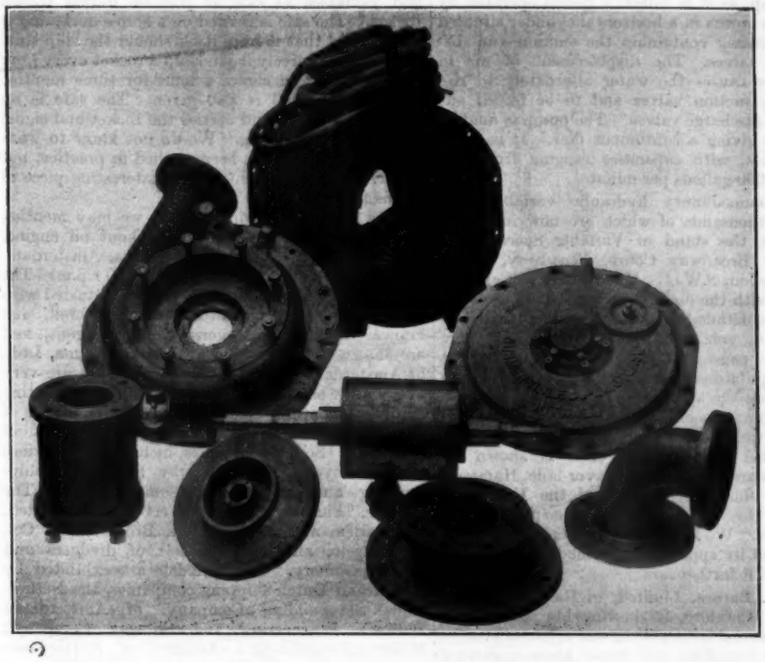


Fig. 43. Parts of Submersible Motor Pump.

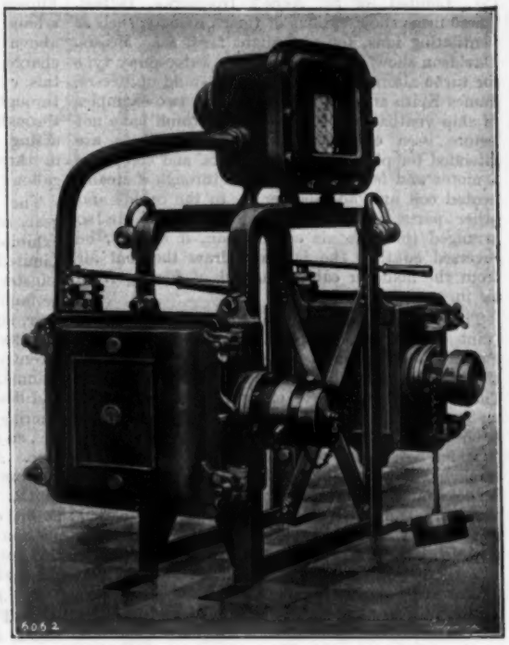


Fig. 44. Switch Gear for Submersible Motor Pump.

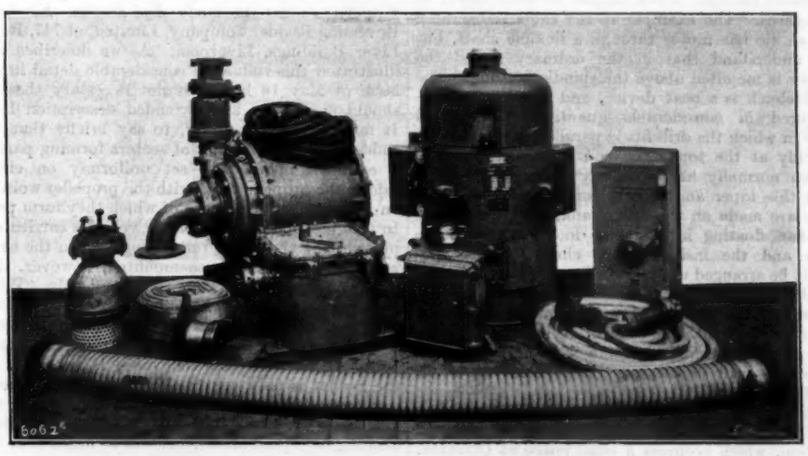


Fig. 45. Auxiliaries for Submersible Motor Pump.

Fig. 42. These sets are intended to be carried by the salvage steamer, or in the case of a big job, can be placed on the deck of a flooded ship. The engine and generator are arranged on a common bedplate which is fitted with wheels so that it can easily be moved, and is designed with lifting shackles that the whole unit may be slung on board a damaged ship. One of these sets is on view at Olympia, and makes a very fine show. The Allen engine is fitted with covers and stuffing boxes, so that it is practically waterproof, and some of those which have been built have been completely immersed in water without their running powers being affected in any way. The engine will, of course, not work under water like the submersible pump, but it will put up with very bad weather conditions or heavy spray. The generator and its connections are completely enclosed.

Our remaining illustrations referring to the submersible motor pump (Figs. 43, 44, and 45, annexed) show one of the submersible pumps disassembled, an example of the watertight switch gear which is used, and a vertical rotary transformer and other detailed gear which is employed in connection with the pump. The vertical rotary transformer, which is shown in Fig. 45 is employed to transform the direct current which is ordinarily employed for ships' generating plant to the three-phase current necessary for supplying the submersible motor. A large number of such transformers have, we believe, been supplied by the company to the Admiralty. Although the submersible motor pump has so far found its main sphere of operation in marine salvage work, it is clear that its qualifications should make it valuable in connection with mining, tunnel work, &c.

We have already dealt with some of the electrical exhibits at the Show, but there are still one or two which we would like to mention. Prominent among these is that of Messrs. Siemens Brothers and Co., Limited, of Palace Place Mansions, Kensington Court, London, W. 8. Messrs. Siemens exhibit in conjunction with their allied company, Messrs. Siemens Brothers Dynamo Works, Limited, of Stafford. The firms have a large stand near the centre of the exhibition and show a large collection of electrical material, mostly relating to ship work. There are fans, loud-speaking telephones, a watertight depth indicator for showing the depth of water in a ship's tanks, or holds, a searchlight projector, &c. There is a navigation light indicator which, we think, is new. This is in the form of a tell-tale board, from which it can be seen at any time if the electric navigation lights of a ship are all burning. The indications are shown on an outlined plan of the ship's deck, which carried illuminated discs. In the case of one lamp of a cluster failing, the bright disc falls to a low intensity of illumination, which is at once noticeable. If the whole of the lamps of a cluster fail, a bell is rung and the disc appears dark. The electrical connections to achieve these effects are simple and will require no enlarging on.

Electrical material is also shown by Messrs. The Electrical Apparatus Company, of Vauxhall Works, South Lambeth-road, S.W., and Messrs. The Igranic Electric Company, Limited, of 147, Queen Victoria-street, E.C. 4. We have described examples of the control gear of both these firms more than once in the past. The Electrical Apparatus Company show various starting and control panels and pillars and drum-type starters, while the Igranic Company show similar material, as also a magnetic lifting magnet, &c. Electrical matters are also represented by Messrs. The London Electric Firm, of Brighton-road, Croydon, who show some very fine searchlight projectors. Two of the projectors shown are of 20 in. diameter, one being intended for commercial work generally and the other being a special pattern for night navigation in the Suez Canal. Messrs. The Sunderland Forge and Engineering Company, Limited, of Sunderland, have an exhibit which also is partly electrical. It consists of a number of examples of their well-known winch, both steam and electric, continuous-current and three-phase motors, &c. Messrs. Marconi's Wireless Telegraph Company, Limited, of Marconi House, Strand, W.C. 2, show a 1½-kw. ship's wireless installation and also have a short range wireless telephone installation working in the hall.

There are several good displays made by builders of fans or ventilating apparatus. Among these we may mention Messrs. The James Keith and Blackman Company, Limited, of 27, Farringdon-avenue, London, E.C.; Messrs. Davidson and Co., Limited,

of Sirocco Engineering Works, Belfast; Messrs. Matthews and Yates, Limited, of Cyclone Works, Swinton, Manchester; and Messrs. Musgrave and Co., Limited, of St. Anne's Ironworks, Belfast. These firms show various of their products, such as ventilating fans, forced-draught fans, &c. Messrs. Davidson show air washers of the water-spray type for turbo-alternators, while on the stand of Messrs. James Keith and Blackman there are two examples of ship ventilating plants which we think have not before been exhibited by the firm. These are intended for placing on ship's decks, and consist of a motor and fan which draw air through a steam-heated coil unit and deliver it to the cabins and other parts of the ship. The dampers are so arranged that the air current can, if desired, be reversed so that the fan will draw the foul air from the holds or cabins instead of forcing fresh air in.

There is an interesting exhibit from a mechanical point of view which appears on the stall of the Patent Rapid Scaffold Tie Company, Limited, of 43, Lansdowne-road, Stockwell, London, S.W. 8. This is the firm whose chain lashing for fixing scaffolds has been so largely employed, and which is so well known. The other exhibit of the firm to which we wish to refer is a form of construction employed for building staging for cranes and derricks, and for elevated platforms for almost any purpose. The construction permits of the erection of towers of a considerable height, three or more of which serve for supporting, for instance, a crane at a height for the erection of tall buildings. The towers are built with four tubular legs, made in sections. The panels at each side of each section are crossed by ties which are screwed right and left hand at the two ends. These ties screw into the sockets into which the main tubular members fit. Spreading of the tower is prevented by plates which fit over the main tubes at each section. These plates lie horizontally, and are made with a large central hole so that ladders may be placed up inside the towers and a man may ascend. The whole construction is very stiff and lends itself to very rapid erection or taking down by few men. The parts are simple and light, and the numbers of different kinds of parts is few. A sample tower built with this construction is to be seen in the yard at Olympia. It is 75 ft. high, and carries a water tank which is used in connection with a demonstration of the work of the submersible motor pump.

There is a good choice of boiler feed pumps at the exhibition, the exhibitors including Messrs. G. and J. Weir, Limited, Cathcart, Glasgow; Robert Warner and Co., Limited, 140, Leadenhall-street, E.C. 3; A. G. Mumford, Limited, Colchester, and others. Messrs. Weir have an imposing selection comprising a pair of direct-acting feed pumps with float tank and automatic control gear, the cylinders being 7½ in. and 9½ in. diameter by 18 in. stroke. A compact centrifugal turbine-driven feed pump, with a capacity of 15,000 gallons per hour is also shown, and parts of the pump are exhibited separately in a show case. There is also on the stand a "Dual" air pump with cylinders 20 in. and 11 in. diameter by 15 in. stroke, of a type doing auxiliary duty for 15,000,000 h.p. of main engines. An evaporator providing 15 tons of fresh water per day, follows well-known lines, but is of interest to land engineers in consequence of the growing tendency to discard softening plants and provide make-up water by evaporation in turbine power stations.

Messrs. Robert Warner and Co., Limited, and A. G. Mumford, Limited, besides boiler feed pumps, exhibit also feed water regulators for boiler feed. The former firm show the well-known Anthony type, on which the regulation of the feed valve is effected by a hydraulic relay operated by the boiler pressure. By turning off a cock the automatic apparatus is put out of action and the feed valve can be regulated by hand in the ordinary way. The regulator was illustrated and fully described in Engineering some time ago. Messrs. Mumford's new regulator we hope to describe later.

An ingenious variant of the various types of hand pump is shown by the Engineering Supplies Company, of 24, Grey-street, Newcastle-on-Tyne. Its special feature is that the water being pumped never enters the working cylinder, and thus, when gritty water is being raised, most of the usual trouble with pumps on this account is avoided. In the Finney pump, as it is called, a piston operated by a hand lever works in a horizontal cylinder situated above the casing containing the suction and discharge flap-valves. The displacement of air in this cylinder causes the water alternately to rise through the suction valves and to be forced out through the discharge valves. The pump is double-acting, thus giving a continuous flow. It is made in three sizes, with capacities ranging from 300 gallons to 3,000 gallons per minute.

The Williams-Janney hydraulic variable-speed gear, some thousands of which are now in use, is exhibited at the stand of Variable Speed Gear, Limited, of Broadway Court, Broadway, Westminster, London, S.W. 1. Our readers will already be familiar with the design and construction of this gear, since a detailed description of it appeared in Engineering, vol. xcv, pages 156 to 157. More recently, see pages 663, 693 and 794 of our last volume, we published a series of articles illustrating and describing the application of the gear to ships' steering gears, winches, capstans, motor vehicles &c., so that we need make no further reference to it here. Another gear of this class is shown by Hydraulic Gears, Limited, of Beavor-lane, Hammersmith, who show applications of the Hele-Shaw pump and the Hele-Shaw variable-speed transmission gears. We have more than once dealt with this gear, and its applications in the past, and need not deal with it further now.

Mr. J. W. Barnes, Limited, of Railway Works, Rock Ferry, Cheshire, is showing his patent drill chuck, a universal lathe milling and grinding attachment and a scarphing and heavy keyway cutting machine for scarphing ship plates, cutting propeller shaft keyways, &c. This last is a neat and semi-portable machine which should be very useful in shipyards. The example at the show is operated by an electric motor through a flexible shaft, but we understand that in the ordinary model the motor is mounted above the spindle housing. The drill chuck is a neat device, and has been manufactured in considerable quantities. The main hole in which the drill fits is parallel, but is tapered quickly at the top. The end of the drill shank, which normally has a slightly rounded edge, fits into this taper and is held centrally by it. Two flats are made on the drill shank, and it is driven by two floating keys, which lock between these flats and the inside of the chuck. Drills may easily be arranged with the drilling machine running. With small drills it is usual to employ a socket fitting the chuck and having a small central hole to carry the drill. The use of such sockets makes one drill chuck suitable for a large range of drill sizes. As will be clear, parallel shank drills are used.

In this, our final article dealing with the exhibition, we must make some reference to the Holland Section, which occupies a large space at Olympia. This section is devoted to exhibits by Dutch firms and has been arranged by a Royal Dutch Commission. There is much in the section to interest visitors, but most of the material does not lend itself to extended technical description. The various models of ships, docks, harbours, &c., is certainly the most striking feature of this section. Some of the models are very elaborate, and we may refer to the relief map of the Netherlands East Indian Archipelago shown by the Royal Packet Navigation Company, of Amsterdam; the model of the quay, sidings, docks, &c., of the Holland Steamship Company, at Amsterdam; maps and plans of Dutch canals, harbours, &c., shown by the Ministry of Waterways; a model of the whole of the port of Amsterdam on a scale of 1 to 1,000, shown by the port authorities; a similar model, to a similar scale, referring to the port of Rotterdam; and models of the same type shown by the Royal Netherland Steamship Company and Wilton's Engineering and Slipway Company, of Rotterdam. Extensive exhibits of maps and similar material are also made by the Dutch Ministry of Colonies and the Netherlands Railways.

Among the more purely engineering material we should refer to the floating ship's safe which is exhibited by N. V. Maatschappy, Tet Explortatie Van Van Blaaderens Dryvende Sheepsbrand-Kasten, of Amsterdam. This is a device for rendering mails and valuables as safe as possible during transit by sea. The safe is carried on a ship's deck, and is so mounted that it frees itself should the ship sink. When floating freely it sends up a rocket every hour for 12 hours and shows a light for three months. An audible signal is also given. The safe is an egg-shaped object and carries the rocket and signal mechanism at the top. We do not know to what extent this device has been applied in practice, but it is certainly an ingenious and interesting piece of mechanism.

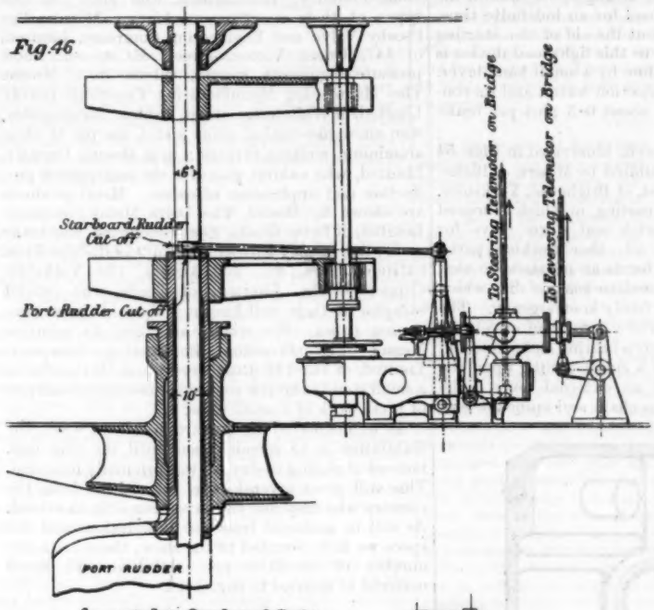
As a pure engineering exhibit we may mention the 180 brake horse-power Kromhout oil engine, which is shown by Kromhout Works, Amsterdam. It is of four cylinders, and runs at 300 r.p.m. The engine is of the semi-Diesel type and is started with a lamp. Its general features are, we think, well known. Sugar-cane wagons, tipping wagons, &c., are shown by Messrs. Du Cros and Brauns, Ltd., of Amsterdam. Some of the ship models are very fine, and we should refer to the examples illustrating dredgers, floating cranes, &c., on the stand of Messrs. "Werf Gusto" Firm A. F. Smulders, of Schiedam. Some nice models, including submarines and destroyers, are shown by the Royal Shipbuilding and Engineering Company, of "The Schelde," Flushing. Messrs. Werf Conrad, Limited, of Haarlem and Messrs. Stork Brothers and Co., of Hengelo, also show models of dredgers and their machinery. Other models are exhibited by the various Dutch shipping companies, the Netherlands Shipbuilding Company, of Amsterdam; Wilton's Engineering and Slipway Company; Messrs. Burgherhout's, Limited, of Rotterdam; and Messrs. J. and K. Smit's Scheepswerven, of Kinderdyk.

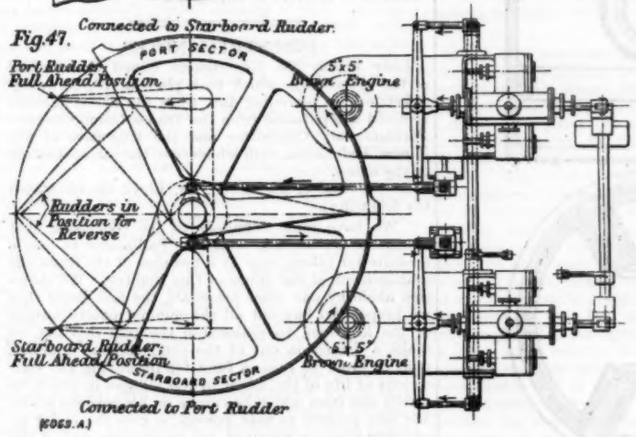
A good display of models and examples of the Kitchen rudder is made by Messrs. Kitchen's Reversing Rudder Company, Limited, of 747, Royal Liver Buildings, Liverpool. As we described and illustrated this rudder in considerable detail in our issue of May 16 last it is not necessary that we should enter into any extended description here. It may be well, however, to say briefly that the rudder consists of a pair of sectors forming part of a cylinder. These are set uniformly on either side of the propeller, i.e., with the propeller working on the axis of the cylinder of which they form part. In this position steering of the vessel is carried out by swinging the whole rudder together in the usual way. The sectors are so mounted, however, that they may also be swung independently. When they are so swung to the full extent they close the after end of the cylinder in which the propeller is working, so that the wake from the propeller is deflected forwards and the vessel is reversed. If the rudder is only partly closed slow speed astern is given, or by adjusting to the correct opening the boat may be caused to stand still with the engines running full speed ahead. It will be noted that the rudder steers and reverses the boat without the speed or direction of rotation of the engines being altered.

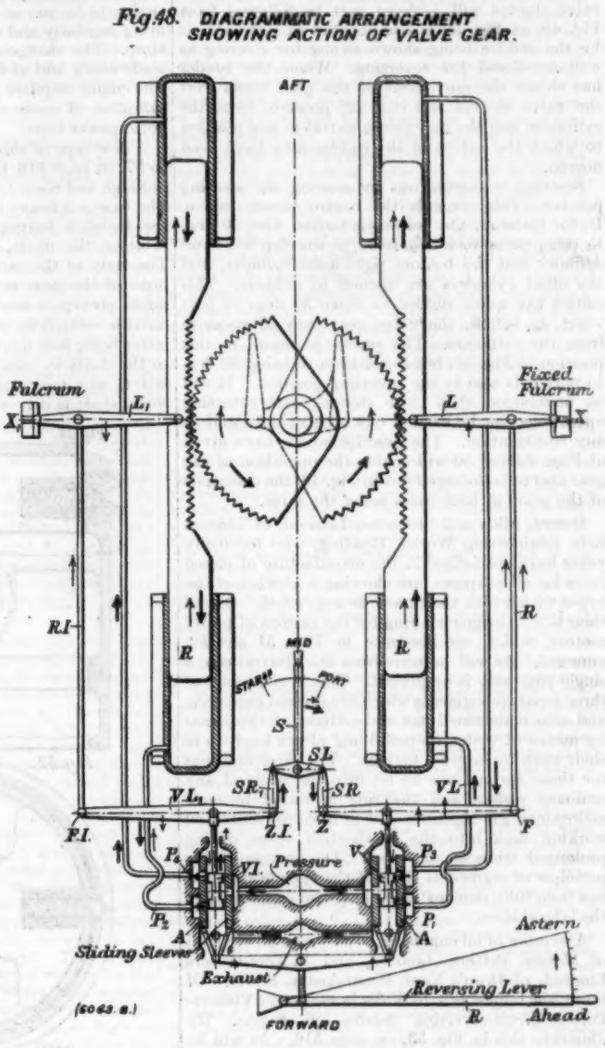
The rudder has been applied to a considerable extent to motor boats and small craft, and records of various tests will be found in our previous description. For application to larger vessels the principle and construction of the rudder itself would not be altered, but arrangements would have to be made for controlling it by a power-driven steering gear. One of the exhibits at Olympia consists of a model of such a power-driven gear arranged for controlling a Kitchen rudder. The gear which the model represents has been got out by Messrs. Brown Brothers and Co., Limited, of Edinburgh, and represents a special application of their well-known gear. We publish two photographic illustrations of the model and drawings, and a diagram of the gear in Figs. 46 to 50, on page 509. The gear itself, which is shown in Figs. 46 and 47, is of the steam-driven type, but Fig. 48 and the model show a hydraulic gear, since this leads itself to a somewhat simpler type of diagram. The valve gear which is shown is suitable in essence for any type of working.

It will be seen both from Figs. 48, 49 and 50

EXHIBITS AT THE SHIPPING AND ENGINEERING EXHIBITION AT OLYMPIA.







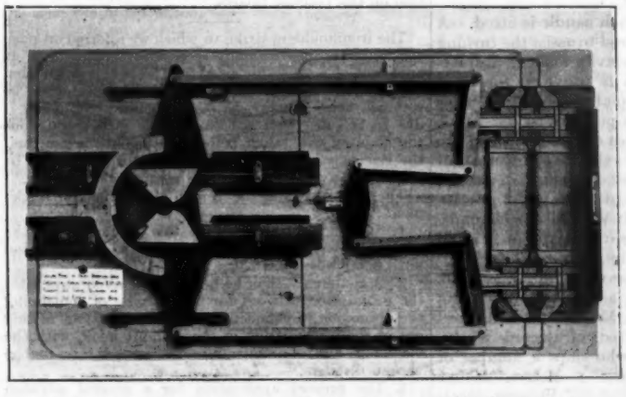


FIG. 49.

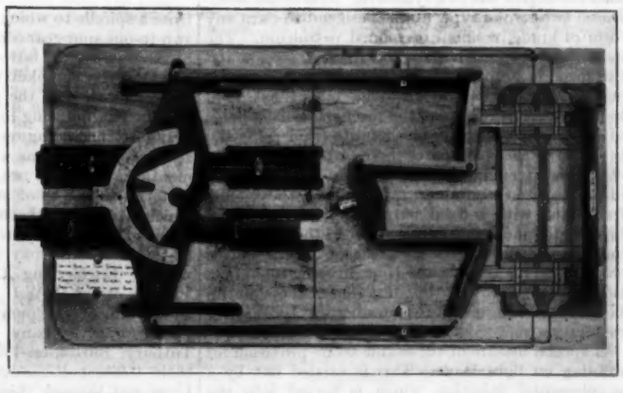


FIG. 50.

FIGS. 46 TO 50. STEERING GEAR FOR KITCHEN RUDDERS; MESSRS. BROWN BROTHERS AND CO., LIMITED, EDINBURGH.

that the essential feature of the valve gear is a pair of sliding valve sleeves which control the reversing, i.e., the opening and closing of the rudder, and a pair of central piston valves which control the steering, i.e., the swinging of the rudder as a whole. The working of the valve gear will best be followed from Figs. 49 and 50, which show the gear in two positions. Considering Fig. 49, in which everything is shown in mid position, it will be seen that each half of the rudder is moved 45 deg. outward from the closed position so that the total opening is 90 deg. The pressure fluid which is controlled by the valves enters by the centre hole and ports which feed the two valve gears. In Fig. 49 these ports are blocked and everything is stationary. In reverse, the reversing bar (which in practice is controlled by telemeter, or shafting, from the bridge) is moved inward to the reverse position in which it is shown in Fig. 50. This admits pressure to the two right-hand ports which feed the two right-hand cylinders. It at the same time puts the two left-hand cylinders to exhaust through the two left-hand ports. The effect of this is that the rudder is closed (as in Fig. 50) and the

boat reverses. The steam, or hydraulic, connections from the ports to the cylinders are shown by means of lines in the figures. This effect of moving the valve sleeves will perhaps best be followed from Fig. 49, as Fig. 50 is complicated to some extent by the rudder being shown swung for steering as well as closed for reversing. When the rudder has closed the movement of the gear hunts over the valve sleeves and cuts off pressure from the cylinders, and the gear comes to rest in any position to which the halves of the rudder may have been moved.

Steering is carried out by moving the steering pointer. This controls the centre piston valves. If, for instance, the pointer is moved over 30 deg. to port, pressure is admitted to the top left-hand cylinder and the bottom right-hand cylinder, and the other cylinders are opened to exhaust. This causes the whole rudder to move 30 deg. to port when, as before, the valve gear cuts off pressure from the cylinders. The rudder is shown in this position in Fig. 50, but in addition to being 30 deg. to port it is also in the reversing position. It will be understood that these steering and reversing operations can be carried out both at once and in any combination. The description we have given of Figs. 49 and 50 will enable the operation of the gear also to be followed out in Fig. 48, the essentials of the gears in both cases being the same.

Messrs. Allen and Simmons, Limited, of Thames Side Engineering Works, Reading, who for many years have specialised in the manufacture of piston rings for all purposes, are showing a number of the types with which their name is associated. One of their latest designs is a ring for the pistons of petrol motors, which we illustrate in Figs. 51 and 52, annexed. As will be seen from the illustrations, a single ring only is employed. This is composed of three separate segments which are pressed outwards, and also maintained gas and oiltight at the joints by means of wedge-shaped filling pieces kept up to their work by internal springs. The three housings for these springs can be let into the walls of any ordinary piston, and the ring is stated to have maintained gas tightness and to have prevented oil working back into the combustion space during prolonged trials on the road. The success of the principle of segmental rings of the type in question has been fully demonstrated in steam engines up to the largest sizes.

A number of oil engines are to be seen on the stall of Messrs. Petters, Limited, and Vickers-Petters Limited, of Dean's Yard, Westminster, S.W.1. Of these, the largest is a 76 brake horse-power Vickers-Petter direct-reversing marine oil engine. We illustrate this in Fig. 53, on page 516. As will be seen the engine has two cylinders. It is of the semi-Diesel two-stroke type, and is desigend to burn any form of crude, residual or refined petroleum. The cylinders are 12 in. in diameter by 14-in. stroke, and the speed is 300 r.p.m. The engine is a very simple one, and operation by unskilled labour has been kept in view throughout the design. It is capable of being started within one minute from cold, and in this respect compares favourably with high-compression engines. The starting lamp consists of a cast-iron container attached to the engine frame and with a fixed burner. After the engine has started, and within one minute, the use of the lamp is dispensed with at all loads. Reversing is carried out by altering the timing of the fuel injection. It is stated that the direction of rotation can be changed an indefinite number of times with certainty.

A special feature of the engine is the provision for running on light loads. This is carried out by a supplemental injection which is forced into the combustion chamber earlier than the normal injection. On single-cylinder engines this is effected by giving an extra stroke to the fuel pump, but in engines of two or four cylinders a connection is fitted whereby one fuel pump may be made to deliver fuel to two cylinders at each stroke, one portion of the charge being injected into the cylinder normally supplied and at the correct timing, while the other portion is injected into the other cylinder in advance of normal timing. In this way each cylinder is supplied with an advanced injection. The early injection is a light one and burns in the combustion chamber, maintaining sufficient heat there to ensure proper combustion of the normal charge. This arrangement enables the engine to be run at no load for an indefinite time, firing regularly and without the aid of the starting lamp. The change-over to this light-load device is made easily and at any time by a small hand lever. The engine requires no injection water, and its consumption of crude oil is about 0·5 pint per brake horse-power hour.

A new type of ship's davit, illustrated in Figs. 54 to 57, on page 516, is exhibited by Messrs. J. Blakeborough and Sons, Limited, of Brighouse, Yorkshire. The base is a heavy iron casting, in which is housed the footstep bearing, clutch and worm drive for rotating the davit, and all other working parts. The body of the casting forms an oil tank, so that none of the gear is exposed to rust or dirt which might prevent it working freely in emergency. The davit is rotated by means of a worm and wheel, the latter being held in a footstep bearing and connected to the davit by means of a clutch sliding upon the latter, and operated by an external lever. The worm shaft is driven by a chain and sprocket gear

Fig. 51.

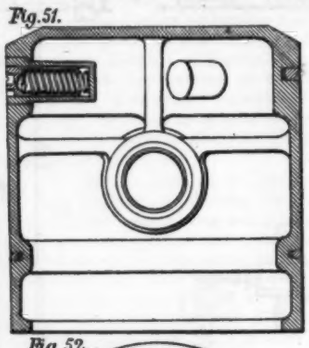
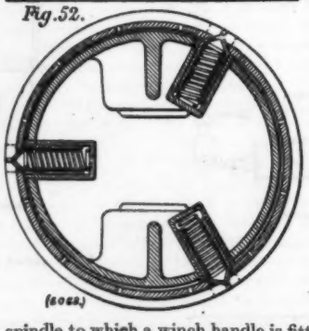


Fig. 52.



from a spindle to which a winch handle is fitted. A two-to-one spur gear can be used to assist the turning of the davit if the latter is heavily loaded. Adjustment of the sprocket chain is provided for by a partial rotation of the gear-plate, the slotted holes seen in Fig. 55 being for this purpose.

Before concluding our series of articles, there are still one or two firms whose exhibits are worthy of mention, although we think in most cases the material shown is of standard type, or of a class which has already been dealt with in our columns. Among these firms there are several exhibiting small oil engines. We may mention Messrs. The Hamworthy Engineering Company, Limited, of 76, Victoria-street, S.W.1, who also show diaphragm and semi-rotary pumps; Messrs. The Record Engineering Company, Limited, of Record Works, Tutbury, Burton-on-Trent, who show a number of their "Silent Record engines"; Messrs. Arthur Lyon and Wrench, Limited, of 36, Victoria-street, S.W.1, who, among other material, exhibit the small petrol-electric sets which were recently dealt with in our columns; and Messrs. Lacy-Hulbert and Co., Limited, of 91, Victoria-street, Westminster. Although there are petrol engines on the stand of this latter firm, their primary exhibit consists of examples of their well-known "Boreas" air and gas compressors, blowers, &c.

Among boiler exhibits we still have to mention that of Messrs. Babcock and Wilcox, of Oriel House, Farringdon-street, E.C., who make a comprehensive exhibit of models of their well-known boilers, conveyors, cranes, &c. More miscellaneous matter is shown by Messrs. W. and T. Avery, Limited, of Soho Foundry, Birmingham, who show various types of their weighing machines; Messrs. The Crosby Valve and Engineering Company, Limited, of 147, Queen Victoria-street, E.C.4, who show pressure regulators, gauges, valves, &c.; Messrs. The Manometer Manufacturing Company (1918), Limited, of Whitehouse-street, Ashton, Birmingham, who show die-casting plant and a sample of their aluminium melting furnace; and Messrs. Ozonair, Limited, who exhibit plant for the commercial production and application of ozone. Metal products are shown by Messrs. The Delta Metal Company, Limited, of Delta Works, East Greenwich, who make a very fine display with samples of "Delta" bronzes, extruded bars, &c., and Messrs. The Yorkshire Copper Works, Limited, of Leeds, who exhibit samples of their well-known "Bemal" brass condensor tubes. We would also like to mention Messrs. The Precision Engineering Company, Limited, of 143–147, Rosebery-avenue, E.C., who on a small stand exhibit a very nice collection of samples of press work of a small class.

As we intimated in our article of last week, the Exhibition is to remain open until the 21st inst. instead of closing to-day, as was originally intended. This still gives several days for visitors from the country who may not yet have been able to attend. As will be gathered from our descriptions and the space we have devoted to the show, there are a fair number of novelties on exhibition and much material of interest to engineers.

INDUSTRIAL NOTES.

Last Friday the Government issued their report of the proceedings which took place at 10, Downing-street, on the preceding day, when the Prime Minister received a deputation from the Trades Union Congress Parliamentary Committee and the Executive of the Miners' Federation, with reference to the nationalisation of the mines.

At the close of his speech, Mr. Lloyd George stated the following:—

"We have come definitely to the conclusion that we cannot see our way to advise Parliament to pass a measure for taking over as a business of the State the management of the mines of this country. We therefore abide by our other proposals, the first being that we propose to buy out all the mining royalty owners of the kingdom, to nationalise the coal deposits, to make a deduction out of the compensation which is paid in order to raise a fund for improving the conditions of life of the miner in the villages in which he dwells and from which he carries on his perilous trade. We also propose to take powers to give the miner an effective voice by means of pit committees and, if the unification scheme is adopted, by means of representation on the District Boards."

The ironmoulders strike to which we referred on page 407 *ante* was provisionally settled last Saturday. It arose out of a claim for an extra 15*s.* per week for men and 7*s.* 6*d.* for apprentices. Work is expected to be resumed next Monday, as stated below; the delay is due to the fact that a ballot of the men throughout the country was taken before the dispute began, and the Executive are under a pledge that a ballot shall be taken on any proposals before resumption of work.

The following are the terms of provisional settlement:—

1. Subject to the terms of this memorandum the present rates of wages shall continue in operation until September 30, 1920.

2. A conference shall be held within seven days after the resumption of work for the purpose of continuing the discussion in connection with the questions arising out of the introduction of the 47-hour week, with the view, *inter alia*, of fixing minimum standard rates for the various districts.

3. The present application for a general advance to be adjourned without prejudice to either party until after the decision of the Court of Arbitration on the next periodical hearing, when it will be considered on its merits and in view of the special arguments advanced. A conference for this purpose to be held within seven days of the announcement of the Court of Arbitration.

4. Subsequent general changes in wages shall be dealt with on a national basis in accordance with provisions for avoiding disputes to be mutually agreed upon.

5. There shall be no victimisation on either side.

6. The men's representatives undertake to submit these proposals to their members, and if they are accepted, to give notice to the Employers' Federations,

so as to permit of a general resumption of work on Monday, October 20.

7. The negotiations shall be conducted on behalf of the workpeople concerned by a Joint Committee, representing the three unions, who are signatories to this agreement.

The agreement is signed for the Engineering and National Employers' Federations by Sir Allan W. Smith, chairman, and Mr. J. McKie Bryce, secretary; for the Society of Coremakers, by Mr. Edmund Clegg; for the Friendly Society of Ironfounders, by Mr. Arthur Henderson, Mr. John E. Davison and Mr. Alfred Todd; and for the Iron, Steel and Metal Dressers' Society, by Mr. C. W. Davidson.

In the expected expansion of industry it is likely that many war-time developments which have proved their own worth will be continued. Such, for instance, is the industrial canteen, which became a popular feature of the munitions works. The First Aid room in the factory was also found to be an asset from the business point of view. In several munitions establishments, now turned over to peace industries, the woman canteen manager, or manager of the ambulance room has been invited to continue her work even in certain cases where men have replaced the war-time women employees. But in new enterprises where women are needed for such work it is of course important that those of the right type of experience shall be engaged. In this connection the Professional Women's Register of the Ministry of Labour, 16, Curzon-street, W. 1, would doubtless be helpful, since hundreds of educated women seeking resettlement are entering their names on the register.

Mr. G. Mure Ritchie, chairman of Palmers Shipbuilding and Iron Company, Limited, speaking at the fifty-fourth ordinary general meeting of that company, on October 1, said that in connection with their iron and steel works they were ascertaining the value of the improvements which they had made. The results they had obtained from the introduction of modern gas-driven blowing engines had been such that the output of pig-iron had been largely increased, with consequently a greater volume of gas produced at the blast furnaces, thus enabling them to utilise a further unit recently added to the gas-cleaning plant, statements which are of special interest in relation to the discussions at the recent meetings of the Iron and Steel Institute. They were now working with three gas-driven blowing engines and six gas-driven electric generating sets, and were putting down a fourth gas-driven blowing engine and a further set of two gas-driven electric generating engines. They were also putting down a third, 60-ton steel furnace. The company were also considering a scheme for handling iron ore, to enable ships of large size to discharge rapidly and to stock their cargo in such a manner that the blast furnaces could be supplied more efficiently than at present, thus effecting, they hoped, a reduction in working costs and enabling them further to increase their output. The question of installing a much larger briquetting plant to deal with larger quantities of fine ores was also engaging the attention of the Board, and when this was in operation, they fully expected that it would prove an additional source of profit to the company. In view of the increasing demand for ship's boilers of large sizes, it had been decided to increase the capacity of their boiler shops. Speaking generally, Mr. Mure Ritchie said this country was in a better position to-day to build for the world than ever before, provided labour would do its part. They could not, however, shut their ears to the ominous sounds of labour discontent they heard on all sides, and see the general disinclination throughout the country to work and produce, without some misgivings. Other nations were making vigorous efforts to secure our trade. We could only avert the inevitable punishment for living on our capital by working and producing as much as possible to replace that capital while there was yet time. That was the only way to prosperity either as individuals or as a nation.

The annual general meeting of the Steel Company of Scotland, Limited, was held in Glasgow on the 2nd inst., when the chairman, Mr. Wallace Thorneycroft, stated that their output for the year under review was less than for the preceding year, chiefly owing to labour troubles. An 8-hour day had been introduced, which required a readjustment of rates of wages all through the works, but it was too early to express any definite opinion on the effect this concession would have on the output and cost of production of the company's products. He was sorry to add that at present the bricklayers employed in all the steel works of the district were on strike for higher wages, and proposals for arbitration had so far been rejected by the men. So far as he knew there was no opposition by any organised employers to whatever improvement may be possible in the standard of living of the lower-paid members of the community, but what standard of living we shall be able to maintain in the future depended largely on our ability to increase our production per head of population, and to dispose of that increased production at a price that will command our share of the world's markets for the finished articles. What that price will be for our steels we do not know, and for a time, Mr. Thorneycroft added, we shall have to take considerable risks in order to keep our works employed.

In the course of his speech at the ordinary general meeting of the Birmingham Small Arms Company, Limited, the chairman, Sir Hallewell Rogers, M.P., made the following statement:—

"One of the foremost questions in the mind of labour to-day is whether the worker is receiving a fair share of the selling-price of goods he helps to produce. Figures are always illuminating, and it is perhaps interesting to know that during last year, for every 1*l.* worth of goods sold, 7*s.* 9*d.* was paid in salaries and wages; 8*s.* 10*d.* represents materials used, the cost of which naturally includes an amount paid in wages by other firms; 2*s.* 4½*d.* taxation, advertising charges, and expenditure on welfare of employees, and of the balance 1*s.* 0½*d.*, part is retained for the stabilisation and development of the business in the interests alike of employees and shareholders, and part paid as dividends to shareholders for the use of their capital. Compared with five years ago, the average wages now being paid to employees have been greatly increased. We do not grudge this increase; on the contrary, we trust that as the cost of living falls it will still be possible to maintain wages which will enable the worker to raise his pre-war standard of living. It is, however, obvious that this must depend upon whether production can be sufficiently increased to enable us to retain our markets and keep our factories fully employed."

In a former issue (see ENGINEERING, vol. cvi, page 641), we called attention to the scheme of co-operative production which Messrs. Priestman Brothers, Limited, Hull, set up at their works. The scheme is described in detail in a pamphlet now issued by the Higher Production Council, 29, Charing Cross, S.W. 1, who advocate its extension, since it would increase production. A number of trade union leaders and men's representatives also recommend it. The council state that the scheme is based on the principle of securing increased production through the co-operative effort of all concerned in the industry, obtained by a common interest in the result. The standard average output per month is ascertained. For purposes of illustration this standard may be designated by 100. If production is increased to, say, 130, under the Priestman system everyone, from the manager to the apprentice, including the office staff, receives 30 per cent. increase on his wages for the four following pay days. Thus a man whose weekly rate of pay is 50*s.* would receive for the four following pay days 65*s.* Where this scheme operates, the result has been so satisfactory that the percentage of increased output has been as high as 80 per cent., and never below 21 per cent. above the standard. The average increase taken from the time it was first introduced is 50 per cent. Four hundred and fifty employees were paid last year additional wages to the extent of 24,000*l.*, and according to the Works Committee, it has produced a feeling of good fellowship between the workmen themselves and a better understanding between the men and management. Certainly the result, as far as production is concerned, has been all that could be desired.

One of the most desirable features of this method is that the results are not brought about by greater individual effort, but are entirely due to the spirit of co-operation and team work between men and departments, the men being anxious to prevent loss of time caused by delay in the transference of work from one department to another, and to the desire displayed by each man to help a fellow workman out of a difficulty. It also adds zest to the men's work because they display the keenest interest in following the progress of production.

Sir James McKechnie, the director responsible for the management of Messrs. Vickers' Naval Construction Works, Barrow-in-Furness, recently asked that a list be submitted to him of the workpeople and staff who had served the firm for forty years and over. The number was found to be 140. Sir James expressed his pleasure at this large number, and decided to make an historical feature of the event by having a photograph taken of the group with himself, on Tuesday last, the 14th inst. On that occasion, in the course of a short speech to the gathering, he stated that he had been at Barrow for twenty-four years, but this service paled before that of some of the men present, a goodly number of whom had put in no less than forty-five years. "It was sometimes asserted," he added, "that the human touch in industry was being effaced, if not altogether lost by reason of the magnitude of the concerns and the numbers employed. He felt, however, that this remark could not be truthfully applied to the Barrow establishment. If evidence were required of the excellent relationships between employer and employed, that evidence was forthcoming in having represented in our group to-day (last Tuesday) a united service of over 6,000 years. Other evidence, however, was not wanting that the relations between the Vickers firm and its workpeople have been unusually harmonious. In the early part of this year, when most of the shipbuilding centres had a prolonged dispute with their men on strike, the works at Barrow did not lose a single hour. I am very proud to be with you and to be the head of the Barrow works which has behind it not only world-wide reputation for its products, but also a universal reputation for its fair dealings with its workpeople. . . . I feel it an honour to be photographed with you; I have pleasure in marking my appreciation of the event by asking each one of you to receive, with my personal compliments and thanks, a 10*l.* note, and I express the hope that each of you may long be spared to enjoy good health and continued and contented employment."

NATIONALISATION OF GERMAN IRON ORE DEPOSITS.

THE proposal for the taking over by the State of the Ilseder iron works and iron ore deposits, meets with marked opposition and adverse criticisms from many quarters. The reason for the nationalisation is stated to be the desire to utilise the largest iron ore property remaining in German possession after the war and the iron works connected therewith, in the interests of the community, the State having expended considerable sums on the development of iron ore production during the war. The sum required for taking over the concern is put at 67,500,000 marks at the outside, added to which is a sum of 12,000,000 marks for further exploitation of the deposits, the State having during the war contributed 30,000,000 marks to the total of 37,500,000 marks applied to development of the ore production. A further 18,000,000 marks will be required for workmen's dwellings. The price of the shares is to be the average of the lowest and highest official exchange from May 7 to June 30, 1919, or 395 per cent., whilst the exchange on August 13 was 483 per cent. The shareholders have the right to bring the matter before a court of arbitration.

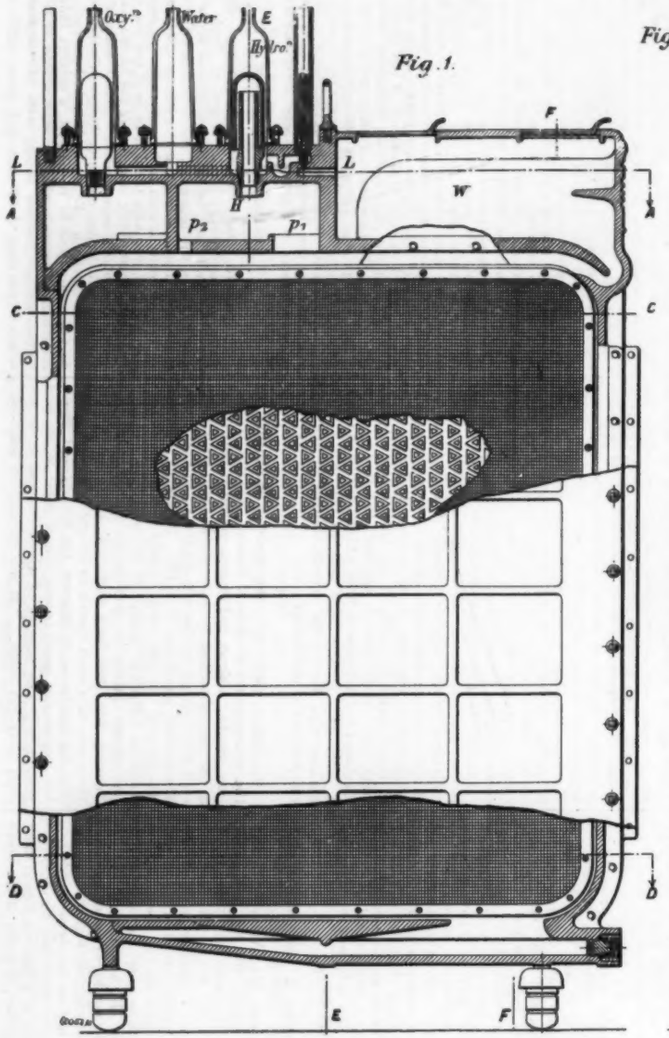
The share capital is 15,000,000 marks, and the last dividend was 32 per cent. The works comprise five blast furnaces in operation and one in the course of construction, with a production of 300,000 tons per annum; the Peiner rolling mill, with a capital of 6,000,000 marks, is entirely owned by the Ilseder concern. The Peiner rolling mill produces about 300,000 tons a year of girders, mining rails, bar iron, &c. This concern is also to be taken over by the State, but it is not intended to work this somewhat complicated undertaking by the State itself. It is proposed to lease it, or perhaps even sell it to the former owners, as long as the State can obtain a sufficient influence upon the management. This rather unusual proposal has caused some surprise.

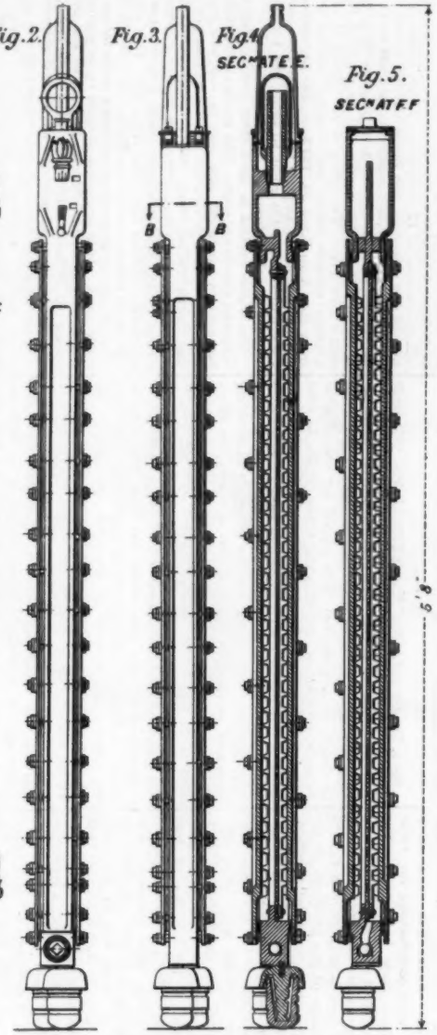
Among the opponents of nationalisation are the board of the Ilseder company. The board protests strongly against the insinuation that the production of iron ore will be insufficient, pointing out that the company, during the war, completely disregarding their own interests, did their utmost to supply other German blast furnaces with ore, and the production was raised from 921,000 tons in 1913 to about 2,000,000 tons. The board also points out that although the Ilseder concern owns the largest iron ore deposits that have been left to Germany after the war, there are other deposits in Germany, for instance, the Frankish Jura, the Siegerland, the Ochtrup and the Lahn ore deposits, where large quantities of iron ore are available. They have certainly not been considered worth working so far, but with the present entirely altered position of the market they may very well be worth attention. The German State can secure them at a much smaller outlay than those of the Ilseder company. It is also being argued that a reckless exploitation of the Ilseder mines for the benefit of other German industries, particularly the Rhenish-Westphalian industry, might soon render it necessary to shut down the Ilseder ironworks and the Peiner rolling mills, to the detriment of the 8,000 hands employed there. This idea, however, seems to be a little premature, as the Ilseder deposits have been estimated by able experts to contain at least 300,000,000 tons of ore.

MANGANESE ORE IN THE IDARWALD, RHENISH PRUSSIA.—According to *The Board of Trade Journal* of September 11 last, workable manganese deposits have been found in the Idarwald, which is a range of wooded hills south of the Mosel, near the Rhine. The existence of these deposits is said to have been known before the war, but the ores were thought to be of too low a grade. The news is surprising considering the ardent search for manganese which was made all over Germany during the war. Rich deposits are, however, reported from Rhannen-Sulzbach, Weitersbach and Hornbruch, about 20 km. south-west of Berncastel, a district famous for its wines. The ore is said to occur within 10 ft. of the surface and to contain 30 per cent. of manganese and about 60 per cent. of iron.

ELECTROLYTIC PRODUCTION OF HYDROGEN AND OXYGEN.

THE INTEGRAL OXYGEN COMPANY, LONDON.





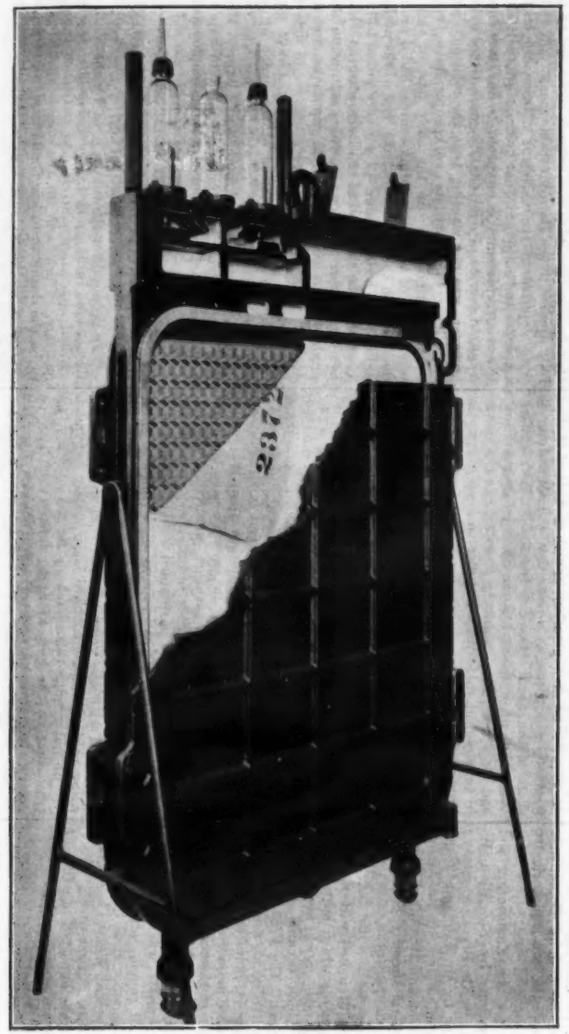
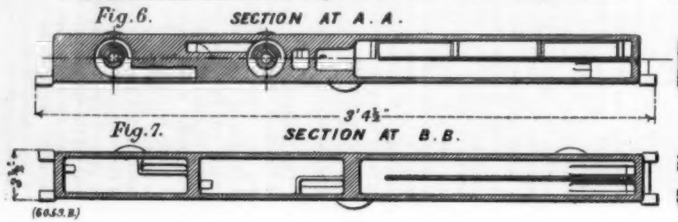
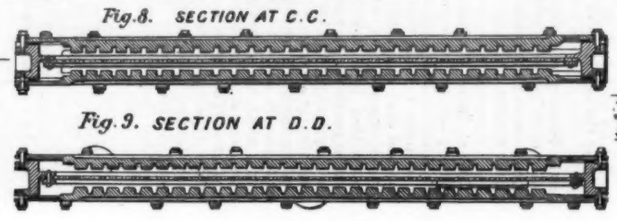
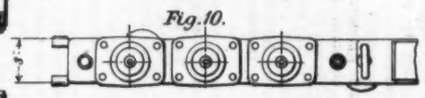


FIG. 11.







ELECTROLYTIC PRODUCTION OF HYDROGEN AND OXYGEN.

THE INTEGRAL OXYGEN COMPANY, LONDON.

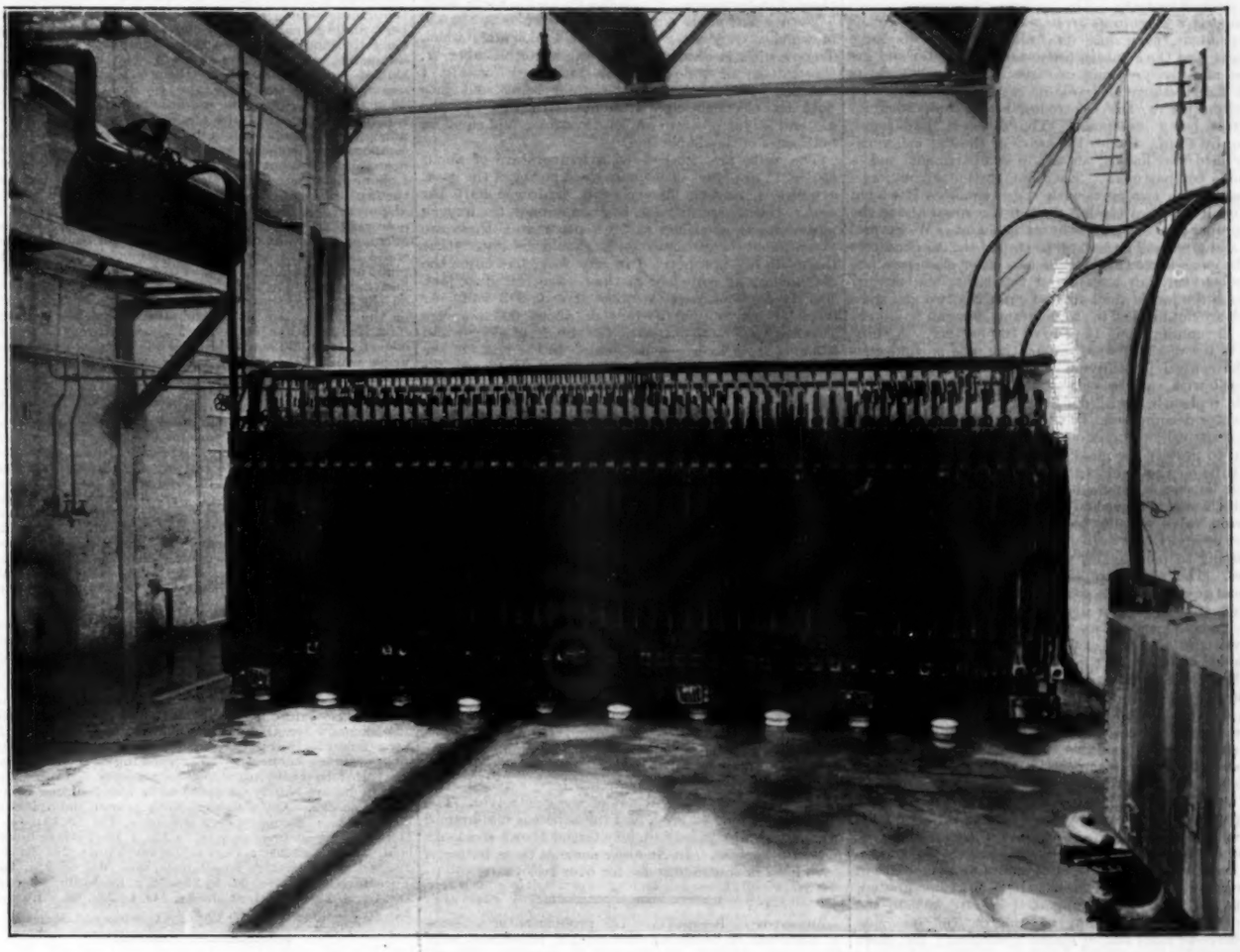
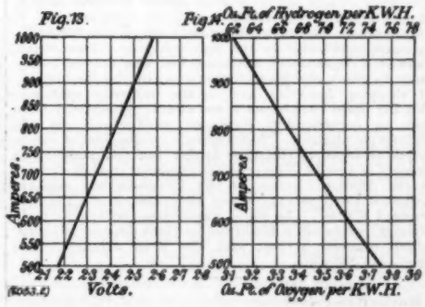


Fig. 12.

Though hydrogen is no longer required in large bulks for the inflation of balloons, the cessation of hostilities has only temporarily checked the consumption of hydrogen. In fact, the war, which has brought home to many engineers and business men how easily hydrogen and oxygen can be generated, will probably lead to an increased demand for these gases, and to their wider appreciation in industrial processes. Where both the two decomposition products of water, hydrogen and oxygen, can be utilised, the electrolytic generation offers advantages over the isolation of hydrogen from water gas, which is the cheaper method when worked on a really large scale.

In the laboratory the electrolysis of water is a very simple matter. Two electrodes are placed in the acidulated water of a glass cell; each electrode is surrounded by a hood, merely an inverted test tube, *e.g.*, in which the gas evolved collects; currents of about 2 volts give one volume of oxygen and two volumes of hydrogen. Quantitatively the relation is given by Faraday's law. One faraday—which is 96,540 coulombs or ampere-seconds = 26·8 ampere-hours, one ampere-hour being equal to 3,600 coulombs—will liberate, at each electrode, one gram-equivalent, *i.e.*, one gram (or 11·2 litres) of hydrogen, and 8 grams (5·6 litres) of oxygen, or altogether 16·8 litres of gas, measured at 0 deg. C. and 1 atmosphere pressure. The technical electrolyser is not quite as simple as the laboratory cell, and the design and construction of automatic apparatus which will continuously yield both the gases in a pure condition of 99 per cent. and more, practically without requiring any attendance, have left sufficient scope for the ingenuity of inventors. Glass cells being out of the question, the container has to be adapted to the electrolyte. Water itself is too



poor a conductor to serve as electrolyte. Either sulphuric acid or caustic alkali, both of about 20 per cent. concentration, are used; but the chemicals are merely to increase the conductivity of the water which is the real electrolyte and has to be replenished by feeding distilled water into the cell; the impurities of ordinary water, notably chlorine, would tend to corrode the apparatus.

The acid is placed in lead containers, the alkali in iron cells. The reversible decomposition of water itself would only require 1·23 volt, but the potential applied has to overcome the resistance of the leads and of the electrolyte and further the polarisation of the electrodes by the gases liberated; sulphuric acid is a better conductor than the alkali, but the supertension of the lead cathode is decidedly higher, hence on the whole the caustic alkali requires a lower decomposition potential. As regards the gas purity and, to a certain extent, the efficiency there is not much to choose between the acid or alkali processes, though the number of kilowatt hours required for the liberation of 1 cub. metre of the two gases varies from 6 down to about 3·5 at volts ranging from 3·6 down to 2·3. But in all these figures the decimals become very important, and there are other features justifying a careful selection of a type of electrolyser. The general preference is for alkali cells. In the Schoop acid electrolyser, the two groups of electrodes, anodes and twice as many cathodes, are all lead tubes, open below to let the acid act on the lead and the lead wires in the tube; each tube is insulated by a refractory hood; the groups are coupled in parallel. In the Garuti alkali electrolyser, vertical diaphragms of iron separate the iron tank into anode and cathode compartments, the two groups of iron electrodes being again in parallel. The Schuckert electrolyser uses insulating diaphragms and places iron hoods in the different compartments to collect the gases. The Schmidt cell of the Oerlikon Company is of the filter-press type, and the corrugated iron electrodes are coupled in series; they are, in fact, bipolar as in some electrolytic copper baths and in bleach cells.

The electrolysers of the Integral Oxygen Company, of 38, Victoria-street, S.W. 1, which we illustrate on the present and opposite pages, differ from the types mentioned above in so far as each cell is a self-contained two-electrode unit and further as to the arrangements made for the regulation of the gas pressure.

In our illustrations the diagrams, Figs. 1 to 10, show a single unit in various elevations and sections; Fig. 11 is a photograph of a cell; Fig. 12 is a photograph of a battery of 100 cells which was, last January,

installed in the Royal Aircraft Establishment, Farnborough; while Figs. 13 and 14 are diagrams explaining the current relations and yield of the cells.

The cells are of the Hazard-Flamand type; the early patents of this cell date back to 1900, but the particular features, the feed and pressure regulation, are later inventions. The battery photograph seems to suggest a filter-press arrangement; but each cell is independent, each has its own feed and discharge devices, and the common features are the water and gas pipes and the grouping in series. Each cell consists of a thin rectangular frame of cast-iron to which two cast-iron plates, the electrodes, are bolted, mica insulators being interposed. The asbestos diaphragm, 36 in. by 43 in., divides the space of the flat cell vertically into two halves, an anode compartment and a cathode compartment. Each compartment communicates through two ports with a gas chamber H which, in Fig. 1, occupies the left part of the space above the cell proper; to the right is the water chamber W. Several jars and pipes will be seen on the top of the gas chamber.

The gases leave through the two outer glass jars, the hydrogen through the jar on the right, the oxygen through the jar on the left, and enter the two gas pipes which are not marked in the diagrams, but can be seen in Fig. 12 running along the top of the battery. A third pipe is the distilled water pipe; this pipe is connected to the central jar through which the cell is originally charged with caustic soda of 20 per cent. and afterwards replenished with distilled water to make up for the water decomposed. Of the two tubes visible on the top of the cell, the one on the left serves merely as a guard to protect the glass jars from being knocked off. The tube on the right is the hydraulic valve. Next to it will be seen a strong hook or eyebolt by means of which the cell is moved. The cell weighs 800 lb. empty. A drain valve will be seen in the right hand lower corner of Fig. 1.

Passing to particulars, we notice first the iron electrodes. The plates are cast of a grey iron with the vertical grooves and the peculiar projections in the shape of truncated triangular pyramids which can be seen in Figs. 1 and 11; the plate thickness is $\frac{1}{4}$ in. Both the grooves and the projections facilitate the circulation of the electrolytic and the liberation of the gases. The width of the cell between the flat tops of the pyramids is about $\frac{3}{4}$ in. The two electrodes are cast the same; they are both sand-blasted and the cathode, which keeps bright in caustic soda, is then ready for use. The anode would be liable to undergo oxidation and corrosion by impurities in the water or caustic, and the anodes of some caustic-cell types hence require renewal after some time. To avoid this the Integral Oxygen Company coats the anodes on the inside with a film of nickel.

The diaphragm is a sheet of asbestos, closely woven. The best asbestos fabric, not containing more than 1 per cent. of cotton, is used. It is not impregnated, nor is the large sheet supported in any way in the cell, except by a framing of iron on the one side (the cathode side) and of elastic insulation; the sheet is clamped between these two frames. When the sheet has been fixed the two electrodes are bolted together and the cell is then hermetically sealed. The elastic insulating material is a mica preparation containing a very small proportion of rubber, just enough to obtain elasticity. Neither rubber itself nor any other organic compounds nor cements are used at all within the cells, though rubber washers and connections have found application outside the cells. It may appear surprising that a sheet of asbestos fabric, however closely woven, will effectually prevent diffusion of the electrolyte and percolations and intermixing of the two gases, generated in the two compartments. But the diaphragms of some of the cell types we mentioned in our introduction are perforated in their lower portions (to promote circulation) without leading to intermixing of the gases, and we are assured that the company never had any trouble from this cause. The high purity of both the gases, over 99 per cent., as we shall see, is moreover a proof that there is practically no contamination of the one gas with the other, and a proof also of the perfect pressure regulation realised.

Of the two ports p_1 and p_2 through which the cell communicates with the gas chamber H, p_1 is the wider and serves as main gas outlet. The cell discharges a spray of gas and caustic; this frothy liquid spreads upon the base plate of H, which has a raised edge next to the port p_1. This ridge prevents the liquid from running back into the port and choking it; the liquid spreads over to the port p_2 and there flows back into the cell; thus a kind of circulation is set up. The gas itself is further deprived of its moisture by having to force its way through a gas trap in the glass jar, which contains an inverted bell of iron, and the liquid is intercepted between this bell and the jar (Fig. 4). The top of the jar is joined to the gas pipe, and any liquid still carried up would flow back into the jar or drip on to the iron bell

The jars referred to are made of a tough glass and are screwed into the top of the cell. The water feed is through the central jar, which does not contain any iron bell. A needle valve (not shown in the diagrams) fits into the top of this jar, in which the water from the water-pipe flows down until it reaches the level LL in the gas chamber H; this level communicates through a bent passage with the hydraulic valve tube. This tube surrounds another overflow tube by the aid of which a constant water head of 4 in. is maintained. The overflow is discharged into the water chamber W, the bottom of which is bent downward, as Fig. 1 indicates, to form a seal, the water being sent into both the electrode compartments. In this way the gas and liquid pressure are kept constant and equal on both sides of the diaphragm.

The cells are worked at a temperature of about 55 deg. C. or more. The guaranteed purity of the gases evolved is, oxygen 99 per cent., hydrogen 99·5 per cent. During recent trials at Farnborough the oxygen purity was maintained at 99·8 per cent.; these are exceptionally high figures. It should be noted that the gases are not purified in any way, but enter the gas holders or cylinders as they leave the glass jars. The average potential is about 2·2 or 2·3 volts per cell; at the normal current of about 600 amperes each cell has a rated output of 4·8 cub. ft. of oxygen and 9·6 cub. ft. of hydrogen per hour. In the trials of the battery at Farnborough, which were continued for days, the amperes were varied between 200 and 1,100 amperes (see Fig. 13), and the volts between 2 volts and nearly 3 volts. Low amperes promise increased efficiency, but at higher installation cost. There will generally be a mean between low installation cost and low operation cost, and this mean has been found to lie between 500 and 800 amperes. The diagram, Fig. 14, explains the variation in the yield of the cell with the amperes, the ordinates of Fig. 14 being the same as those of Fig. 13. The yields of nearly 4 cub. ft. of oxygen and twice as much hydrogen per kilowatt hour are very satisfactory.

We should have mentioned that in coupling the cell up to a battery distance pieces of steel are bolted to flanges on the cells, and the cells are thus connected in series. This method of coupling does not interfere with the high flexibility of the battery; a cell can easily be added or removed, and the current can, of course, be varied in the usual fashion.

One of the Integral Oxygen Company's cells is now shown in the Olympia Exhibition (No. 226 on the Gallery). This cell has done service for nine months; the iron cathode looks rusty, but that is the fault of the atmosphere to which the plate has been exposed after the cell was emptied, and not of the electrolyte. The anode has remained grey, and the asbestos diaphragm, originally white, is only slightly tinged brown and looks perfect otherwise. In America some of these batteries have been in continuous use for over two years.

Asbestos in Rhodesia.—The production of asbestos in Rhodesia is becoming increasingly important, says *The South African Mining and Engineering Journal*. The districts in which it is found are those in Bulawayo and Victoria. Production commenced in 1908, and has grown from 55 tons in that year to 8,574 tons in 1918. If to that we add the production for the first five months of the present year (2,940 tons), we have a total of 31,139 tons. The value of the 1918 output was 158,684*l.*, as against 189,820*l.* in the previous year. The output showed a decrease of 988 tons, but was due to heavy rains in the early part of the year, to the inadequacy of shipping facilities and to the influenza epidemic. But for these drawbacks there would undoubtedly have been a considerably increased production. In the Bulawayo district, Willoughby's Consolidated is a producer from its Birthday mine; but the quantity at present is small. The greatest producer in that district is the Shabanie mine, of the Rhodesia and General Asbestos Corporation, whose May output of 260 tons realised 6,524*l.* The same corporation, in the Victoria district, produced in May from its Gath deposit 167 tons, which realised 4,196*l.*, and the King asbestos mine produced 200 tons.

Motor Ship Converted to Steamship.—The Glenpool, formerly the German motor ship Hagen, is being converted to steam power for the Standard Oil Company, New Jersey, at the Mariners Harbour yard of the Staten Island Shipbuilding Company, Staten Island, N.Y., says *International Marine Engineering*. This vessel was originally built in 1912, at the Krupp Germania yard, Kiel, for the German-American Petroleum Company. She is 400 ft. long between perpendiculars, 53 ft. beam moulded, 32 ft. 4 in. depth at side to upper deck, and has a net tonnage of 3,087, a gross tonnage of 5,459, and a deadweight tonnage of over 8,000 tons. Power was formerly supplied by two single-acting two-cycle Diesel engines capable of developing about 1,500 h.p. each at 140 revolutions, giving the ship a speed of 11 knots at full load. The new machinery, built by the Staten Island Company, consists of three single-ended Scotch boilers, fitted with Howden's system of draught, two triple-expansion engines capable of developing 1,200 i.h.p. each at 100 r.p.m., when supplied with steam at 190 lb., and with the necessary auxiliaries.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—If the moulders return to work on Monday next, the chief obstacle to progress in the South Yorkshire engineering and steel industries will be removed. On all sides it is sincerely hoped that the moulders' national ballot will confirm a settlement on the lines indicated. Though strenuous efforts have been made to carry on the engineering and steel trades since the moulders came out, production has been badly hampered, and large numbers of semi-skilled and unskilled workers have been thrown idle. This week's unemployment total for the Sheffield area exceeds 20,000, which equals the maximum reached during the railway strike, when the staple trades generally were affected. Considerable numbers of steel workers temporarily displaced by the railway strike have since been reinstated, but the total on the books of the Sheffield Labour Exchange proves that an equal number has been thrown idle owing to the continuance of the moulders' dispute. The dearth of castings, heavy and light, is now making itself seriously felt. Not the least serious effect is in actual steel production, the crucible steel trade being held up for lack of moulds. Repairs to plant and machinery owing to lack of castings have also been delayed. The same factor has reacted unfavourably on the building trade. Special attention is being paid at the moment to motor car steel. One of the large East End firms has just secured an order from an English concern, for 3,000 rear axles, and one of the more modern firms which is directing its enterprise to automobile construction has received an order for 400 motor cars of one of the latest designs. Export trade, though unsatisfactory in some respects, improves in others. Wire, galvanised sheets and steel plates are going away in increased tonnages to foreign markets. More orders have also been received for hardware, tubes, pipes and tinned plates. Since the railway strike manufacturers of files, saws and other light steel goods have continued the wider employment of motor lorries for inland delivery. In some cases goods are being sent to places as far distant as London, the recipients being willing to pay for the extra cost of transport because of the decided saving in time through the avoidance of the usual railway delays. The market for raw and semi-finished materials is unchanged, though imports of American material are slightly on the increase.

South Yorkshire Coal Trade.—Business in the open market continues at a low level. The reason is that efforts are being directed almost solely to the discharge of delayed contract commitments. The collieries, though working better, have not yet got over the railway strike. Outputs in some cases are irregular, and a further period must elapse before normal conditions are fully restored. The demand for all qualities of manufacturing fuels is very heavy. Railway companies and electricity and gas-producing concerns are pressing for increased deliveries to build up depleted reserves. House coal merchants are chiefly occupied with the building up of winter stocks. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.* Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* 6*d.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Arrival of a small cargo of French foundry iron at a port in Scotland purchased, it is stated, at considerably below the present price of Cleveland foundry pig-iron, has been much commented on here, but traders do not regard the occurrence with anything approaching alarm, the opinion prevailing that the incident is not likely to be repeated to any great extent, though it is realised that present rate of exchange may permit of one or two further similar transactions. Against this unpalatable news the market presents welcome favourable features such as the probable end of the foundrymen's strike, and the fact that blast furnaces are working a good deal better than was looked for after the enforced idleness. Some furnaces indeed, thanks to an ample supply of coke, have developed great heat, and consequently produced good quality of iron. At the same time large output of inferior descriptions must be counted on as the result of the recent stoppage. For a while furnaces are bound to work unsatisfactorily. For home consumption, No. 1 Cleveland pig-iron was 164*s.*, and No. 3 g.m.b., No. 4 foundry and No. 4 forge all stood at 160*s.*; whilst export prices were 5*s.* above these rates.

Hematite Iron.—Home buying of hematite is not extensive just now, but improved foreign demand is noticeable. Good Belgium and Italian inquiries are reported to have resulted in some business. Stocks held in Italy which were bought some time ago at comparatively cheap rates are understood to have been used up. Nos. 1, 2 and 3 East Coast brands are 200*s.* for home purposes, and 205*s.* for shipment abroad, and No. 1 is 202*s.* 6*d.* for home use and 207*s.* 6*d.* for export.

Foreign Ore.—There is little or nothing passing in foreign ore. Consumers continue to hold off the market. They are not necessitated to buy as they are carrying considerable stocks, and have substantial contracts made. Imports, however, show a very marked falling-off. So far this month, unloadings are only about

one-third of those for the corresponding part of September. Nominally rubio, of 50 per cent. quality, is 53*s.* c.i.f. Tees.

Coke.—There is a good deal of activity in coke. Deliveries are on a considerable scale and would be heavier but for congestion on the railways and truck shortage. Supplies to local blast furnaces have been surprisingly satisfactory, however. Average furnace kind is 48*s.* at the ovens and low phosphorus quality 49*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Work is in full swing once more at the finished iron and steel establishments. In some branches contracts are running out, and are not being replaced, but in other departments manufacturers have good order books, and report fairly good inquiries. Demand for shipbuilding material and railway requisites are good. Values, all round, are upheld. Export quotations are still matter of individual negotiation, but may be given as rather above the following, which govern home trade:—Common iron bars, 22*l.*; marked bars, 25*l.*; strip iron, 23*l.* 5*s.*; black sheets, 24*l.*; galvanised sheets, 30*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel angles, 17*l.* 15*s.*; steel boiler plates, 21*l.* 10*s.*; steel joists, 17*l.* 10*s.*; and heavy steel rails, 16*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Conditions in the coal trade are still unsettled. Although there is a fair supply of tonnage in dock, many collieries are awkwardly placed in this respect. At the same time loading berths are insufficient to meet shippers' requirements and consequently exporters able to arrange quick loading can secure supplies at substantial concessions on quoted prices. The demand for inland consumption is heavy and collieries have been instructed to resume deliveries forthwith. Large quantities are also being sent to home ports for bunkering purposes. Notwithstanding this, available supplies for free coal are sufficient to meet the immediate demand for the reason that licences are coming along slowly for export, and shippers in a number of instances are temporarily out of the market. The continuance of the ironfounders' and steelworkers' strikes also lessens the demand, and collieries, in many cases, are ready to make sacrifices in order to secure a quick release of empty wagons so that the pits can be kept working regularly. Best Admiralty and Monmouthshire large coals are worth no more than 82*s.* 6*d.*, drys 80*s.*, and the cheaper descriptions from 75*s.*, though for spot loading buyers can obtain a reduction of 2*s.* 6*d.* on these prices. Best small steams are relatively steady at from 60*s.* to 62*s.* 6*d.*, but ordinary and inferior smalls are plentiful at from 50*s.* and 37*s.* 6*d.* respectively. Bituminous coals, too, are in fair request, with prices steady on the basis of 72*s.* 6*d.* for No. 2 Rhondda large, and 62*s.* 6*d.* for throughs. Coke and patent fuel remain scarce and command 105*s.* and 80*s.* respectively. Pitwood is plentiful and weak from 50*s.*

Iron and Steel Trade.—There is a good inquiry for materials of all descriptions and prices are firm generally. Though tin-plate manufacturers are suffering from a shortage of water, about 70 per cent. of the mills are working, and as much as 39*s.* per box has been paid for ordinary 28 by 14 tin plates, which is a record price. The demand from abroad is good, but makers are not inclined to take on forward business. Tin and sheet bar makers have plenty of orders on hand, and 14*l.* 5*s.* to 14*l.* 15*s.* has been done over next year. Quotations for galvanised sheets are on the basis of 35*l.* f.o.b., for early shipment, and 33*l.* for 24-gauge corrugated bundles. Scrap is quieter at 7*l.* 10*s.* for heavy, and some sellers are ready to take 5*s.* less.

Big Shipping Deal.—Messrs. W. R. Smith and Sons, Cardiff, have acquired the seven steamers managed by Messrs. Letricheux and David, Limited, Swansea. Financial details of the transactions have not been disclosed, but it is estimated to involve about 750,000*l.* Messrs. W. R. Smith and Sons now control the largest fleet managed by any single South Wales firm, having 23 steamers of over 160,000 tons deadweight under their management. Messrs. Edwards, Sons and Co., Limited, Cardiff, managers of the Western Counties Shipping Company, Limited, have refused an offer for the management interests of the company. The Western Counties company own four steamers of 23,700 tons deadweight.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The settlement of the strike of the railwaymen gave hopes that we were assured a period of rest from labour troubles and that general trade would open out, but another unfortunate strike, by the Lanarkshire steel works bricklayers, now seems like dashing the above hopes to the ground. The demand was made for an increase of 9*d.* per hour, making 2*s.* 7½*d.* per hour, but on this being refused by the masters the request was reduced to 4½*d.* per hour. This latter was also refused and the employers suggested arbitration, but as the bricklayers declined this, the deadlock continues. Not only are some 25,000 men being directly affected, but many of the shipyards and other users of steel are having their operations retarded owing to the want of material. This further dislocation of the general trade in the West of Scotland is very unfortunate indeed, and as the majority of the steel works are at present partially idle the stocks of steel held by consumers are rapidly decreasing. The demand for plates has been very pressing owing to the activity in the shipyards, and, if the latter are to carry on, supplies must be obtained from other districts. In sectional material there is not so much doing, but hopes are entertained that an improvement may soon take place in this branch of the industry. The black sheet trade is in a healthy condition and makers have plenty of orders to fulfil, especially for the heavier gauges. Prices have been advanced, and sheets of ⅛-in. gauge are now quoted at 23*l.* 10*s.* per ton f.o.t. makers' works, and 24*l.* per ton f.o.b. Glasgow. The export trade is very dull and little business is passing in any branch of the steel industry.

Malleable Iron Trade.—In the malleable iron trade of the West of Scotland there exists a good demand for home consumption, and order books are well filled up. The present state of affairs assures steady running for some time. In the export side of the business there is not a heavy tonnage going through. Prices are firm and unchanged.

Scotch Pig-Iron Trade.—During the railway strike some of the iron works were able to continue operation, and there is now more material available. A healthy demand exists for most qualities of pig-iron, principally on home account. No. 1 foundry iron is rather scarce. Last week the total amount of pig-iron shipped from Glasgow was 325 tons 10 cwt., of which 307 tons 10 cwt. went foreign.

Engineering.—The various engineering shops in Glasgow area are all well employed, and much activity prevails. The railway strike caused some trouble with regard to supplies, but as it was of short duration the inconvenience was not detrimental to the trade, and as plenty of fuel, &c., is now available operations are not being hindered meantime.

Institution of Engineers and Shipbuilders in Scotland.—The opening meeting of the Institution of Engineers and Shipbuilders in Scotland will take place on Tuesday, November 11, when the president, Dr. T. Blackwood Murray, will deliver his presidential address, and a paper will also be read on that evening by Professor E. C. Coker, of London University. During the ensuing session the Institution will return to their own quarters in Elmbank Crescent, Glasgow, which are at present being reconstructed after having been used as the headquarters in Scotland of the Ministry of Munitions during the war. After having been suspended for the duration of the war, the Junior Section of the Institution will be revived this winter, and a successful session is anticipated.

TIN EXPORTS FROM THE FEDERATED MALAY STATES.—It is reported from Kuala Lumpur that the export of tin from the Federated Malay States in the month of September amounted to 3,161 tons, as compared with 2,955 tons in August and 3,166 tons in the corresponding month last year. The total for nine months amounted to 28,261 tons, as against 28,336 tons in the corresponding period last year and 29,572 tons in 1917.

NON-FERROUS MINING IN THE UNITED KINGDOM.—The committee appointed by the Board of Trade to consider and report upon non-ferrous mining in the United Kingdom held its first meeting after the recess on October 13, under the chairmanship of Mr. H. B. Betterton, M.P. It has decided to deal in the first instance with tin-mining, and the committee will proceed to take evidence. Subsequently, the committee will take up the question of zinc and lead mining.

TELEGRAPHY AND TELEPHONY.—We are informed that a course of six lectures on "Thermionic Detectors, Oscillators and Amplifiers in Telegraphy and Telephony," will be delivered at University College, London, by Professor J. A. Fleming, M.A., D.Sc., F.R.S., on Wednesdays at 5 p.m., beginning October 29, 1919. The course is open both to members and non-members of the university. The fee is 1*l.* 11*s.* 6*d.*, and application for tickets of admission should be made to Mr. Walter W. Seton, M.A., D.Lit., University College, London (Gower-street, W.C. 1).

ANGLO-DUTCH TRADE RELATIONSHIP.—At an Anglo-Dutch dinner given by the president, vice-presidents and committee of the International Shipping, Engineering and Machinery Exhibition, and the chairman and members of the Royal Commission for the Holland Section, on Wednesday evening last, at Olympia, Sir Owen Philipps, who presided, said that the Royal Commission for the Holland Section had cordially co-operated in making the exhibition a success. He hoped that the joint effort would tend to enhance the goodwill existing between Great Britain and Holland, and that Rotterdam and Amsterdam would in future handle a considerable portion of the trade which previously passed through German ports. The Royal Mail Steam Packet Company and its associated companies, he said, had lost during the war over 500,000 tons of shipping, which was being replaced as rapidly as possible, though at an enormous cost. Both British and Dutch shipowners would have to face in the near future a difficult period, in which obsolete ships would have to be scrapped, as only the most modern vessels would be able to hold their own. Exhibitions, such as that at Olympia, were of service in bringing the latest improvements to the notice of those who were ready to take advantage of them. His Excellency, the Dutch Minister, in replying, said that although the Dutch people had remained neutral during the world conflict, they had not lost sight of the question of right and wrong between the fighting parties. The Dutch and British people understood each other, and he thought that the friendly relationship, thus cemented, would prove of great mutual benefit in the future.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 17, at 7.30 p.m., at 39, Victoria-street, Westminster, S.W. 1. Lecture: "The Manufacture of Collapsible Metallic Tubes," by Mr. E. R. Sharpe, Member. Friday, October 24, at 7.30 p.m., at 39, Victoria-street, Westminster, S.W. 1. Lecture: "Fire Prevention and Protection in Factories and Workshops," by Captain Stanley W. Thorpe, Chief Officer Kodak Fire Brigade.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Monday, October 20, at 6 p.m., a meeting of the Graduates will be held at The Institution, Storey's Gate Paper: "Production," by Mr. C. H. Adams, Graduate. Chairman: Captain H. Riall Sankey, C.B., R.E., Member of Council.

THE BRADFORD ENGINEERING SOCIETY.—Monday, October 20, at 7.45 p.m., a lecture will be given in the Hall of the Technical College, by Mr. W. H. Owen, M.Inst.C.E. Subject: "The Extraction Turbine and the Utilisation of Exhaust Steam."

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, October 21, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. The following paper will be read: "Some Laboratory Tests on Mineral Oils," by Mr. Arnold Philip, B.Sc., A.R.S.M., F.I.C. The chair will be taken by the president, Sir Frederick W. Black, K.C.B.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 24, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Address by the president, Mr. Edward Hopkinson, D.Sc., M.P.

THE INDUSTRIAL LEAGUE AND COUNCIL.—The second lecture of the series arranged by the Industrial League and Council (incorporating the Industrial Reconstruction Council and the Industrial League) will be held in the Council Chamber of the Guildhall, on Tuesday, October 21. The chair will be taken by the Right Hon. J. H. Thomas, M.P., and a lecture will be delivered by Mr. E. J. P. Benn, on "Should Wages be Lowered." Applications for tickets should be made to the Secretary, Industrial League and Council, 66, Victoria-street, S.W.1.

H.M. DESTROYER WITHERINGTON.—On Friday, the 10th inst., Messrs. J. Samuel White and Co., East Cowes, Isle of Wight, delivered to the Navy a new and powerful destroyer of the "W" Class, the Witherington. The Witherington was laid down on July 29, 1918, and launched on January 16, 1919. She is of 1,450 tons displacement and 28,000 shaft horse-power. During extensive and satisfactory trials at Skelmorlie in the early part of September she attained a speed of 35 knots. She has been constructed, engined and fully equipped by Messrs. White, her propelling machinery consistng of two Brown-Curtis geared turbines, supplied with steam from oil-fired White-Forster water-tube boilers. Her armament consists of superimposed guns fore and aft, anti-aircraft high-angle guns and triple sets of torpedo tubes amidships. This is the seventy-first torpedo vessel completed by the firm, several of which have earned undying fame during the past war.

PERSONAL.—The Richmond Gas Stove and Meter Company, Limited, have now removed to their new premises at 164–172, Queen Victoria-street, London, E.C. 4. They hope to have the show-room portion of the building finished in a few weeks. All communications intended for their London offices should now be sent to their new address. Their telegraphic address remains as at present, namely, "Gasapparatus, Cent, London," their telephone number is altered to City 7450 (3 lines).—Mr. W. W. Blunt has retired from his post of director of the Metropolitan-Vickers Electric Company, Limited, and head of its commercial organisation, to take up an active partnership in an engineering business with his brother in the United States. To mark the occasion, his colleagues from Trafford Park and the district offices met at dinner at the Midland Hotel, Manchester, on the 10th inst., to honour Mr. Blunt and wish him every success. Captain R. S. Hilton, managing director of the company, who was in the chair, said in the course of his speech that it was a source of gratification to know that Mr. Blunt retained a connection with the company.—Messrs. Walter P. Notcutt, Limited, 8, White-street, Moorfields, London, E.C., have re-engaged each of their men as they became demobilised from active service, and have added to their staff of travellers, Mr. C. T. Richardson and Mr. G. H. Truman.—The Empire Roller Bearings Company, Limited, having placed their services at the disposal of the Ministry of Munitions and suspended their ordinary business during the war, have now resumed active operations at No. 13, Victoria-street, Westminster, and will in future be closely associated with Messrs. Ransomes and Rapier, of Ipswich and London, of which Sir Wilfred Stokes, K.B.E., is the chairman.—The Triplex Safety Glass Company, Limited, state that Messrs. Handley Page, Limited, have been appointed sole agents for the sale of Triplex safety glass in India, Australia, New Zealand and South Africa, and all inquiries with regard to business in the above-mentioned countries should be sent to them.—Allied Industries, Limited, announce that they have removed from 6, Crosby-square, E.C., and that their address is now 18, Eldon-street, London, E.C.2.—Messrs. Richard Garrett and Sons, Limited, inform us that they have opened an office at 11, Globe Chambers, Side, Newcastle-on-Tyne, and that Mr. H. Keay Pratt, M.I.Mech.E., A.M.N.E.C.Inst. (for several years chief of their Technical Department) has been appointed their District Representative for the North of England.

EXHIBITS AT THE SHIPPING AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 504.)

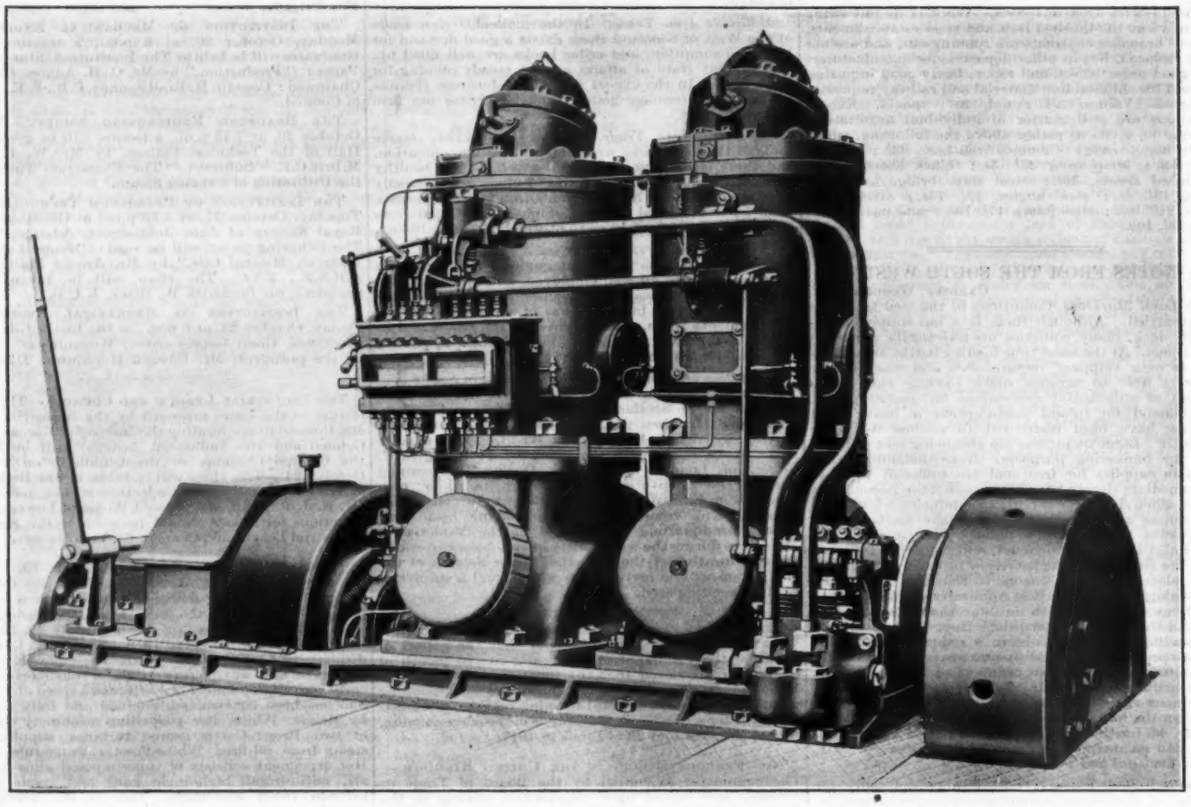


Fig. 53. 76-B.H.P. Direct-Reversing Marine Crude Oil Engine; Messrs. Vickers-Petters, L'm:ted, Ipswich.

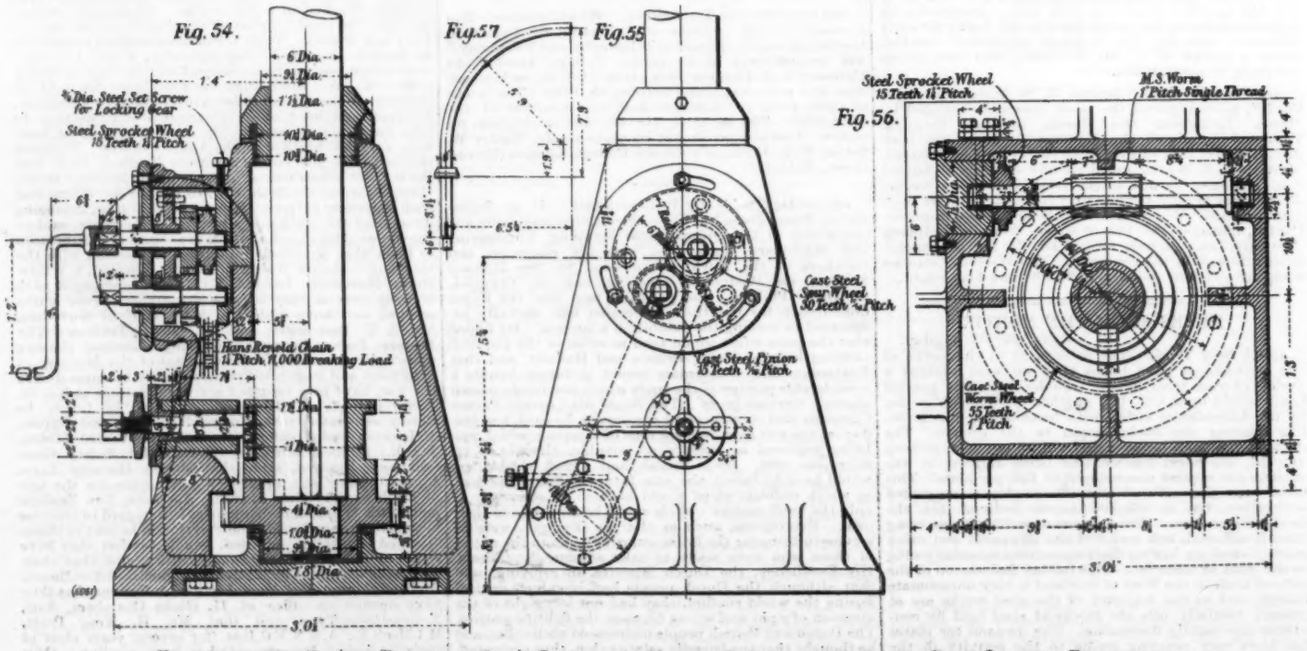


Fig. 54.
Fig. 57
Fig. 55
Fig. 56.
Steel Sprocket Wheel 15 Teeth ¼" Pitch
M.S. Worm 1" Pitch Single Thread
Cast Steel Spur Wheel 30 Teeth ½" Pitch
Cast Steel Pinion 15 Teeth ½" Pitch
Cast Steel Worm Wheel 55 Teeth 1" Pitch
Hans Renold Chain ½ Pitch 11,000 Breaking Load
3'01"

Figs. 54 to 57. Turret Davit for Ship's Lifeboats; Messrs. J. Blakeborough and Sons, Limited, Brighouse.

Fig. 51. Upper Portion of Backstay Completed; Six Panels Erected.

Fig. 52. Upper Backstay Connected to Top Chord at Point 11.

BRIDGE, NEW YORK.

LINDENTHAL, CHIEF ENGINEER.

(Description, Page 499.)

FIG. 54. TRAVELLERS AT CENTRE OF SPAN COMPLETING ERECTION OF TRUSSES.

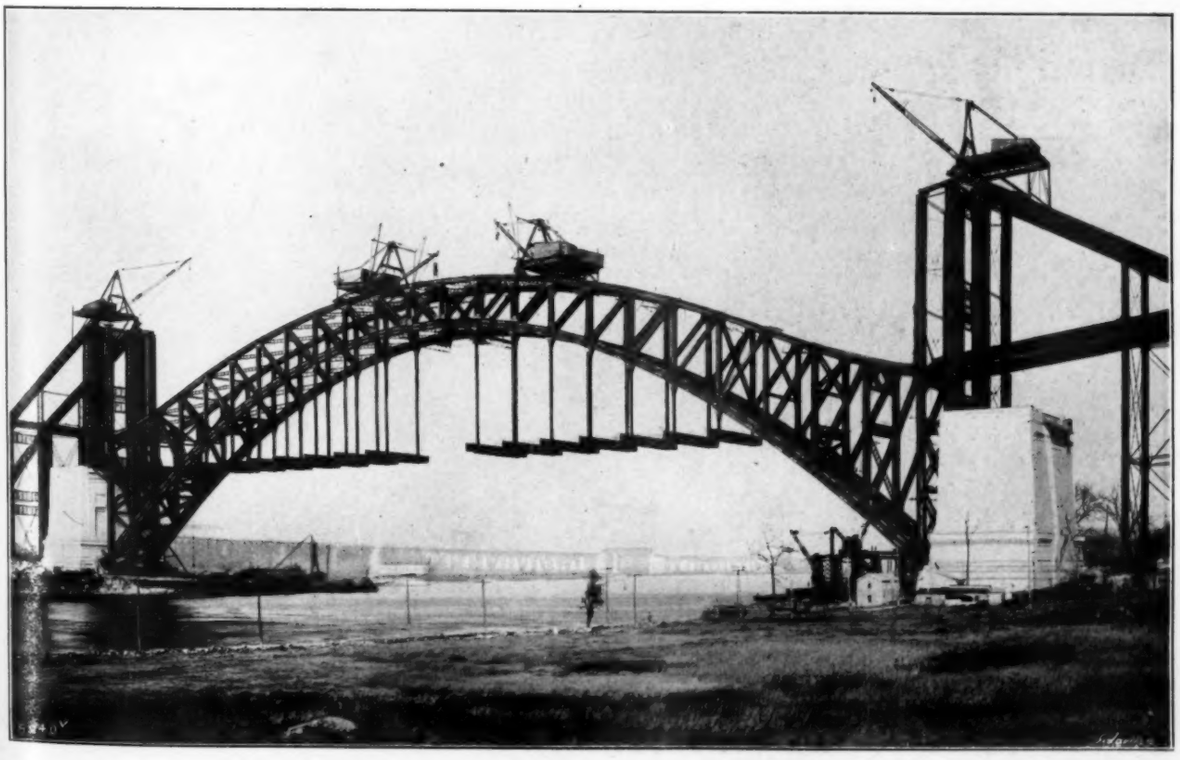


FIG. 58. BACKSTAYS BEING REMOVED AND FLOOR BEAMS BEING ERECTED

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3863 and 8598 GERRARD.

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With a Two-Page Plate of the HELL GATE BRIDGE, NEW YORK.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 515.

ENGINEERING.

FRIDAY, OCTOBER 17, 1919.

THE BRITISH GLASSWARE INDUSTRY.

THE glass industry stands prominent among those that have suffered in the past by a detachment, more or less complete, from its scientific aspects. German energy and organisation, perceiving its opportunity, first improved the manufacture and then captured the trade. Importation became general: beakers and flasks and the whole of our heavy chemical hollow ware were imported, our manufacturers gave no encouragement to the craftsmen, but tamely followed in the wake of the triumphal progress so loudly acclaimed from Jena and Vienna. A few firms—that of Messrs. Chance, of Birmingham is an honourable example—refused to bow the knee to the German claims of superexcellence, but a large proportion has been content to assemble the parts and sell the ware so easily and cheaply placed at their doors. With the outbreak of war, the goods disappeared, and it was found that much of the art of manufacture had been lost. As with other goods, essential in commerce as in war, no attempt had been made to organise production, private enterprise and private interest being supposed sufficient to meet all emergencies. The trade was in a parlous state and it is greatly to the credit of those, who, with every prospect of a short-lived prosperity that would not survive the war, endeavoured to promote an enlarged production on scientific lines, and to educate the British public in the belief that a home-made article might possess the beauty or the efficiency of the German product. Unless the Government could be persuaded to control the prices of imported glass or to impose a duty on glassware, there could be little hope of retaining the industry after the conclusion of peace. As the Government hesitates to declare any precise policy in reply to the appeal of the several associations representative of the glass trade, we may fail to keep possession of so much of the industry that has been recovered by enterprise and perseverance. The conditions are more arduous than in 1914, when information and experiment were needed but competition was absent. The trade has had to bear the cost of systematic investigation and to meet the increased price of materials and labour. Furnaces that have been working for some time continuously require renewing, causing expense and delay, at a time when German activity, long dormant, is reviving after its enforced repose.

But though the outlook may be uncertain or depressing that should not prevent our generous appreciation of those who have striven to remedy the backward condition of the trade, and to remove the paralysing influence of years of neglect. Much has been accomplished that tends to revive manufacture and to defeat German competition. Foremost among those who have struggled to promote the glass trade stand Dr. W. E. S. Turner and his coadjutors, who were instrumental in persuading the University of Sheffield to found a department of glass technology, and to provide courses for instruction and facilities for research.

In securing the support and prestige of a University the founders have been fortunate, but though the home is in Sheffield the effort is broad-based and national. The Delegacy for Glass Research, of which Sir W. E. Clegg is chairman, is democratic in its aims and invites further co-operation. As at present constituted, the committee embraces university professors and staff, glass manufacturers, and representatives of labour. The work of the delegacy is divided into four committees who control respectively the Lampworking School, the Pot Furnace Works Problems, the Tank Furnace Works Problems and the Technical Education and Training. Funds have been generously subscribed by the Yorkshire Association of Glass Bottle Manufacturers, the Flint Glass Manufacturers' Association, and the Association of Bottle Manufacturers of Great Britain and Ireland. The British Chemical Ware Manufacturers and the British Laboratory Ware Associations have also co-operated. The Department of Scientific and Industrial Research contributed 1,500*l.* towards the equipment of the laboratory and an annual grant of 1,200*l.* for five years. On account of special work undertaken for the Ministry of Munitions, a sum of 3,000*l.* was voted to enable the plant to be erected on a semi-commercial scale. This varied support implies no ephemeral effort but suggests that the Institution is conceived on lines of permanent utility. The maintenance of close contact with actual industrial needs is considered of prime importance, and suggestions as to subjects for research and investigation are invited from those practically interested in particular inquiries. Designed on such a reasonable basis, the delegacy has been a success from the first, though the number of its pupils has fluctuated with the urgency of military recruiting.

The erection of the entire equipment of the laboratory has been much delayed by the same causes that have hindered construction work elsewhere. Melting on a large scale has been prevented by the poorness of the gas, and has had to be suspended entirely while a booster was installed on the gas system. The melting plant now comprises a series of pot furnaces having a capacity of 28 lb., 56 lb., and 1 cwt. to 2 cwt., in addition to some small scale melting facilities. Cables for electric melting operations have been installed and preliminary experiments have been in progress. A small model lehr, electrically heated, has been designed and partly built in the department and found to work satisfactorily. The staff of research workers, exclusive of Dr. Turner, is at present five. The number of pupils now availing themselves of the facilities provided is about forty. The courses are arranged in length to meet special needs, the complete course extending over a year. The plan adopted permits a manufacturer to send a pupil for a month or longer to receive instruction in some special process, and in this way more scientific methods will gradually permeate the whole trade. Disabled soldiers are sent for training by various pension committees throughout the country. Some of these apparently unpromising cases have given most satisfactory results. At the present time a discharged soldier with only a finger and a thumb on one hand has made remarkable progress.

The programme of original work while varied and extensive, is of an eminently practical character, as shown by the following items which indicate the nature of the problems that have been under recent consideration: the production of neutral tinted optical glasses; of a glass affording protection to electric steel melters; and of red glass of a special tint. The theoretical work includes an investigation of the attack of chemical reagents on glass surfaces; the determination of the effect of magnesia on the melting point, mechanical strength, workability, and other properties of glass; the production of a soft easily workable glass, free from lead, for lamp working and for electric lighting bulbs; the condition of annealing of different types of glassware.

The list is far longer than can be reproduced, but these may serve as a sample. The inquiry into the attack of chemical reagents on glass surfaces is of particular value, for it is precisely on the production of a reliable resistant glass, one free from the defect of giving off alkaline deposits in water, that the claim to German supremacy rested. The Jena glass, admittedly suitable for analytical investigations, has maintained its hold in the scientific world, solely by reason of this quality of resistance, the result of long continued systematic investigation into the factors which influence the stability and durability of glass. Accumulated experience and patient research had given the Germans a long lead, but with determination this may be recovered. The discipline of the war has done much to discredit

the value, or the inviolability, of so-called trade secrets as a possible road to success. Samples of glass can be analysed, the materials employed and the proportions in which they are mixed, become known, the general principles of glass manufacture are common property, and experiment with perseverance brings about a successful result. The aim of the Sheffield chemists was not to produce something which might serve as a makeshift, or substitute, till time should bring back the only genuine and trusted resistant glass. It can be recorded with justice and satisfaction that our glass manufacturers are now in a position to produce a glass that in many essentials is better than the German best. The reputation of Jena glass for resistant qualities is deservedly high, if the test be water, but it is poor for other reagents, as caustic alkali. The only test to which importance is attached at the Reichsanstalt is the capacity to resist the action of water, and with this view the glass is well tested from 20 deg. C. to 80 deg. C., but at Sheffield the glass is submitted to five tests with water and steam, four with caustic or carbonated alkali, and two with hydrochloric acid. It is an unexpected result to find that sodium carbonate can have a stronger action than caustic, and this is especially the case if alumina is absent from the glass. This peculiarity suggests the possibility of designing a glass, which should be highly resistant towards a particular reagent. Undoubtedly this is demonstrated by experiment, but the object is to produce a good all round glass, equally resistant under all circumstances, and this standard the Jena glass does not meet to the same extent as those recently manufactured in this country. Probably a practice will arise of employing different types of glass for different analytical researches, as it would not be difficult to select a glass resistant to the particular reagent employed. It should, however, be possible to provide a successful compromise that satisfies general requirements, and the wider use of alumina in the composition offers the most promising results, as it provides a constituent that is fairly resistant against water, acid, and alkali alike, but the melting and working might be proportionately difficult.

The durability of glass or its resistance against fracture on sudden changes of temperature are points of no less importance than the solution by water or acid of the constituents of the glass itself, and as these qualities depend mainly upon annealing, an operation that affects the profits of an undertaking very materially, this subject has been studied carefully and is still receiving attention. It is curious to note that the polarising test, proposed by Sir David Brewster a century ago, is little known and practiced, except in the case of optical glass; an example, if any were needed, that the discoveries of pure science do not find application in the direction in which they would prove most useful. The optical test is the only known method which involves no risk to the glass, and it is one which will record the rate at which annealing is proceeding. No doubt the manufacturer has practical rules for the removal of strain depending on mechanical tests, which his experience has enabled him to systematise, but the substitution of results derived from the application of rigorous methods should be preferable, and probably more economical, especially if the factory does not adhere to the making of one type of glass. The facts of which precise information is needed, are, the temperature at which strain can be removed rapidly without causing the glass to undergo deformation; the lowest temperature at which it is possible to remove strain; and the quickest rate of cooling between these two temperatures at which glass can be safely cooled without any recurrence of strain. One result of the Sheffield work is to demonstrate that a comparatively small alteration of temperature in the lehr affects the annealing to a marked extent, and may not only make all the difference between a well and an imperfectly annealed glass, but will greatly accelerate or retard the process. For instance, between the temperatures 600 deg. and 630 deg., it was found that each rise of five degrees reduced the time for annealing by one-half. This is rather a high temperature for annealing, in the case of a light lead glass at a temperature of 425 deg., the time necessary to produce an entirely black field was 130 minutes, while at 450 deg. only 12 minutes were needed. This indicates the possibility of passing articles through the lehr much more quickly, affecting considerable saving in time and fuel.

The mechanical method of testing the progress of annealing by softening the glass is in more general use, and here a considerable alteration in the normal practice is recommended. The quickest safe way of cooling a glass is not by making equal decrements of temperature in equal times, but rather by stages. Just below the annealing temperature the glass may be cooled at a rapid rate, for while in this condition any stress caused by sudden cooling is quickly remedied, but as the glass stiffens, the rate of cooling must be decreased, and the slow rate continued till the glass becomes rigid, for if a stress be introduced at a low temperature more time is necessary to remove any stress that is set up. This variation in the rate of cooling suggests the desirability of constructing the lehr in sections, in each of which the temperature could be suitably adjusted, and the rate of passage through successive stages accommodated to the gradual cooling. Chemical composition affects the upper critical temperature for annealing and the most appropriate rate of cooling to such an extent that it is not possible to give precise thermometric values. Lead glasses are all very easily annealed at about the same temperature of 450 deg., although the contents of lead oxide may vary materially. Boric-oxide heat-resisting glass requires a temperature of 585 deg., and is much more difficult to anneal, especially between the limits of 500 deg. to 360 deg. Chemical glassware is the most difficult of all and has to be raised to a temperature of about 630 deg. With some specimens the difficulty of annealing is so great, that notwithstanding the most careful manipulation, it is impossible to prevent the glass showing some signs of stress.

The Sheffield University and those associated with the movement are to be congratulated on the success they have achieved in their early days, and on the public spirit they have evinced in assisting the nation in its hour of need with little hope of permanent reward. If successful competition with a rival and well established foreign industry is to be maintained, they have adopted a proper method for upholding the nation's interests in the unequal contest.

CO-OPERATION IN MANUFACTURES.

The advisability, nay, the eminent necessity, of British manufacturers abandoning their traditional policy of a splendid isolation for one of mutual aid and co-operation was repeatedly emphasised during the earlier years of the war. Indeed, even before that catastrophe broke upon a (for the most part) unsuspecting world, some progress had already been made in this direction. In one notable instance in which a British firm had entered into a contract for a foreign Government, under very onerous conditions, they were surprised to receive from one of their principal competitors an offer to put at their service, without fee or reward, the whole of the special experience of his staff. The proffer was prompted by the consideration that a failure to meet the very exacting terms of the contract would not tend to enhance the prestige of British engineers and would be exploited for all it was worth and more, by our Continental rivals.

Under "the ties of common funk" created by the war, similar acts became frequent. Shipbuilders whose experience had been gained solely in mercantile work, were impressed into the construction of destroyers, and would have fared badly had it not been for the help of every kind received from firms who had specialised in this particular class of construction. The stress has now been relaxed, but the work of reconstruction will benefit greatly by the maintenance of a spirit of co-operation amongst our manufacturers. No doubt the establishment of the various technical research associations will do much to foster this.

In the engineering trades the need for mutual help is not less insistent, although recent consolidations will at any rate ensure the future co-operation of many previous competitors. In the past this competition has not always been conducted on sane lines. In a presidential address to the South African Institution of Engineers, delivered some three or four years ago, an amusing picture was drawn of the tactics followed on the Rand by certain firms of steam turbine builders, who appeared to think that the best recommendation for their own wares was to enumerate all the troubles, real or imaginary, to which competing makes were liable. To paraphrase Gilbert—

> "Their argument was novel,
> For the contract they relied,
> By totting up the troubles
> That a turbine might betide."

As a not unnatural result of this style of advocacy a reciprocating plant was often installed in conditions far better suited for the rival type of prime mover.

This excess of rivalry between competing firms has encouraged a policy of secrecy which has not been for the good of the profession. Young engineers have been kept as ignorant as possible of work or experiments in progress and denied, so far as practicable, opportunity for gaining experience, which would enhance their market value. It was considered better not to train up a thoroughly competent man than to run the risk of his being attracted away by a competitor. American manufacturers have been more farsighted in this regard. When some very special and expensive experiments were being made some years ago by a leading American firm, the question arose as to whether the young engineers taking part in the work were to be informed as to the object in view or to be kept as far as possible in the dark. The matter was settled in favour of the former alternative on the ground that it was from these young engineers that the heads of departments must be selected in later years. Consequently the more experience and knowledge they gained the more valuable their services were likely to be.

One way in which engineers can well co-operate is by increasing the support given to our technical societies. This is well pointed out in a circular just issued by the North-East Coast Institution of Engineers and Shipbuilders. The papers read at the meetings of these societies are of use and benefit to the whole of the profession. The burden of providing them, however, falls on the members only, and there are large numbers of engineers in all our manufacturing areas who still fail to realise that it is their duty to lighten this by themselves becoming members and not merely members but active members of a technical society.

Too many, as it is, join up with the intention of taking all they can get and giving as little as possible in return. Even some eminent engineers have been obsessed with this mental attitude. We have known a leading water works engineer (now deceased) refuse particulars of a singularly difficult piece of well-sinking he had succeeded in effecting by novel means, on the ground that he did not wish "to give the process away." He was, of course, a member of the leading Institutions. The proceedings of these, however, would have benefited him little had all the other members adopted a similar policy. It must, however, be admitted that even our leading technical institutions have at times accepted papers of little or no technical value. At first glance the papers may have appeared frank and informative, but a closer study often shows that essential details have been of set purpose suppressed. The most instructive type of paper is no doubt that dealing with the features and difficulties which necessarily come in practice. For obvious reasons, however, it is only in special circumstances that such happenings can be publicly discussed.

SHIPBUILDING YARDS IN AUSTRALIA.

Industrial conditions existing in the United Kingdom at the present time appear to be distinctly favourable to the establishment of new industries abroad, and, even more so, to the development of those industries which have already made some headway. As this fact is, perhaps, not so fully realised as its importance merits, it may be of some value to refer to shipbuilding in Australia as an instance of the class of industry likely to benefit from the changed conditions in the United Kingdom. A few years ago the relative cost of labour and materials in Great Britain and in Australia was such that competition on commercial lines had hardly

to be considered, but the establishment of steel works in Australia, and the greatly increased cost of labour and materials here, must tend to bring the cost of shipbuilding in the two countries more nearly to the same level.

Some interesting particulars of the work of Australian shipbuilding yards up to the commencement of this year are given in a paper read by Mr. J. Leask, M.I.N.A., before the Melbourne Section of the Junior Institution of Engineers. At Sydney there are four yards, of which the most important is the Cockatoo Island Yard, now owned by the Commonwealth Government. This yard formerly belonged to the New South Wales Government, and was at first employed on general repair work, docking and slipway work. Little or no new building work was carried out until an order was placed for the construction of the light cruiser Brisbane, and work on the hull of this vessel was well advanced when the yard was purchased by the Commonwealth Government. The destroyer Warrego, constructed by the Fairfield Company at Govan, was shipped to Sydney and re-erected at Cockatoo Island. This work, as well as that on the Brisbane, having proved entirely satisfactory, appears to have given a fresh impetus to the Australian shipbuilding industry. Since that time another light cruiser, the Adelaide, has been launched, and three destroyers have been completed, as well as lightships, launches and other small craft. There are at present under construction a fleet collier and a cargo vessel for the Commonwealth Government line of steamers. The former vessel is the first steel ship to be built entirely of Australian material. It is designed to carry 4,000 tons of coal, 1,250 tons of oil, and 750 tons of fresh water for the Fleet, as well as about 1,000 tons of bunker coal.

The principal work of the Morts Dock, Sydney, is dry-docking, slipway work and repairs, although various types of vessels have been constructed for local owners, and two oil storage vessels were constructed in 1912 and 1913 for the Australian Navy. Messrs. Morrison and Sinclair, another Sydney firm, are builders principally of wooden ships, and Messrs. Poole and Steel, formerly of Sydney, have now removed to Adelaide, where they will probably build vessels for the Commonwealth Government line. Owing to the suitability of local timber, Tasmania seems to be best adapted for the construction of wooden ships. There are two firms at Hobart, viz., Messrs. Purdon and Featherston, and Messrs. Kennedy, engaged in the construction of this class of vessel. There is also a shipyard at Devonport, Tasmania, where it is understood that two vessels for the Commonwealth line are to be built. Williamstown Shipyard, near Melbourne, originally owned by the Government of Victoria, has recently been taken over by the Commonwealth Government. The constructional work consisted chiefly of dredging plant, but dry-docking and repairs were also carried out. Two vessels are now under construction for the Commonwealth line. Messrs. Grey Brothers, of Williamstown, have successfully carried out the important operation of lengthening a vessel, and have also constructed some dumb hopper barges, but are not now engaged in shipbuilding work. Hopper barges have also been constructed by Messrs. Johnson and Sons, of Melbourne. Wooden ships have been built from time to time at a few establishments in Queensland, and vessels for the Commonwealth line are about to be constructed at a yard at Maryborough. Pearling luggers are also built by Japanese labour at Thursday Island.

One of the most recently-constructed yards, and one which promises largely to influence the shipbuilding industry in Australia, is that at Walsh Island, Newcastle, N.S.W. The yard is situated in a coal centre and is directly opposite the Broken Hill steel works, where plates, sections and steel castings are produced. Its favourable location should be of material assistance in the matter of cheap production. Dredgers, hopper barges, trawlers and other craft, have already been built in this yard, and six steamers for the Commonwealth line are now in course of construction. There is ample room for extension, and a dozen berths could easily be laid down if required. The yard, which is under the management of Mr. A. M. Bomphrey, has its own engine shops, so that vessels can be constructed and supplied complete with machinery. A considerable number of launches have been built in other establishments in Australia, and doubtless some of these yards could be adapted for the construction of larger vessels. It would thus appear that the shipbuilding industry of the Commonwealth has a very promising future, and although it is, of course, preferable for Australia to construct her own ships than to purchase them from foreign countries, it must not be forgotten that one of our means of paying for the Australian produce we need will be diminished by the development of the Australian shipbuilding industry.

THE BRITISH ASSOCIATION.

(*Continued from page* 471.)

In continuing our comments on the Transactions of Section A, Mathematical and Physical Science, we may mention first another paper on "Radiotelegraphy." This was of a technical character; the discussions abstracted in our issue of the 10th inst. dealt with the general physical problems of radiotelegraphy and thermoionic valves.

Wireless in the Royal Flying Corps.

The communication which Major T. Vincent, M.C., made under the title of this paragraph was of the nature of a lantern lecture on the work of the Military Wing of the Royal Flying Corps during the first three years of the war, bringing the history of the work up to the time of the amalgamation of the Corps with the Naval Air Service into the Royal Air Force. With the aid of many slides Major Vincent dealt in detail with the state of knowledge at the beginning of the war, with the great difficulties they had to overcome, and with the gradual progress made.

A Possible Theory of Vision.

In presenting suggestions of a "Possible Theory of Vision," Sir Oliver Lodge stated that he had, in 1894, pointed out that the rods and cones of the retina might act as Hertz resonators responding to the transverse vibration of luminous waves. The subsequent discoveries of radioactivity and of the structure of the atom might explain how the nerves became stimulated, a question then left obscure. An atom struck by waves of a very high frequency emitted K radiations from the innermost electrons, and L and M radiations from those further out. The electrons at greatest distance from the nucleus, which were held responsible for chemical reactions, might respond to radiations of the character of visible light; there was sufficient space probably in an atom of 10^{-8} cm. radius for the orbits of the electrons of red, green and violet light. He therefore suggested that the retina might contain atoms in a state of instability (somewhat like the subgenerative state of which Dr. Eccles had spoken with reference to thermoionic valves) ready to be excited by light pulses of suitable frequency into expelling electrons and into stimulating the nerve. The energy would be that of the light pulses, accumulated within very short periods of time on the principle of syntony; that would account for the peculiarity of the eye, which was exceedingly sensitive to light and not sensitive otherwise. In order to admit of tri-chromic vision the tuning should not be too precise, for the eye could not distinguish between a pure yellow and a mixed yellow; in that connection, Sir Oliver Lodge drew attention to experiments of Professor Barton and Miss Browning (in the *Philosophical Magazine* of September, 1919), whose damped pendulums exhibited phenomena somewhat analogous to colour vision.

In the discussion Professor A. W. Porter asked, whether this photoelectric theory would not require more than three types of electrons, and Dr. Lindemann submitted that the visual purple was too complicated for this simple photoelectric theory and that chemical effects probably intervened.

Sir Oliver replied to these and other objections, that he did not restrict himself to three frequencies, though he would like to remain faithful to Helmholtz. The chief aim of his communication was that he wished to have experiments made with recently-removed retinæ in order to ascertain, whether they emitted electrons when excited by green, red and violet radiations. That would make the eye an electric sense-organ. Professor Gray was ready to accept that suggestion, but we had to work out the detail.

Seismology.

Two communications were presented on seismology, the first by the committee on "Seismological Investigations," by its chairman, Professor H. H. Turner, F.R.S., of Oxford (Mr. J. J. Shaw, of West Bromwich, is secretary), and the second on "Seismology after the War," by Dr. G. W. Walker, F.R.S., of Oxford. Both the papers dwelt on questions of general policy and organisation. Professor Turner stated that the International Research Council, sitting at Brussels July 18 to 28, had constituted a Geodetic and Physical Union, with seismology as one of its sections. The resolution involved the establishment of a seismological bureau or central office, to collate and discuss records and to carry out research and standardisation work, and it had been hoped that some locality in England, probably Oxford, might be selected. Previous to the Brussels meeting, a National Research Council for Geophysics had been constituted under the auspices of the Royal Society and had resolved that an offer should be made by the Section of Seismology of the International Union of Geodesy and Geophysics to locate its central bureau at Oxford, the executive committee to have power to transfer the bureau to another locality in Great Britain eventually. At Brussels, however, the French had urged the claims of Strasbourg (Strasburg had before the war been the seat of the International Seismological Association under Hecker), and a division of the Bureau's work between Strasbourg and Oxford was suggested; since, however, the relations with that association remained to be settled, the constitution of a Seismological Section was deferred. On the other hand, a change of locality had become inevitable for other reasons. Mrs. Milne had decided to return to her home country, Japan; that involved the sale of Dr. J. Milne's house and observatory at Shide, Isle of Wight, and the instruments were being transferred to Oxford. One of the Milne-Shaw seismographs was set up again in October, 1918, just in time to catch the big Porto Rico earthquake that month. The report dealt further with corrections suggested for tables and with earthquake periodicity. An examination of the catalogue of Chinese earthquakes, compiled by Milne and Hirota, gave indications of periods of 39 years and 26 years, both these numbers being multiples of 13.

Professor Turner also referred to the study, by the late Boris Galitzin, of the records of the explosion which occurred at Okhta, 8 miles north-east of Petrograd, on April 19, 1915. The shock was recorded both at Petrograd and at Pavlosk, and there were simultaneous barograph records indicating only a small change in air pressure, however, of 0·3 mm. As regards this feature Galitzin had pointed out that barographs, placed as usually in sheltered buildings for routine work, were not suitably mounted for recording sudden shocks. The chief point was, however, that the origin of the earth-crust wave was not distinct on the three records (N.S. and E.W. components, vertical component), whilst a second shock 70 seconds later was very distinct. Galitzin first thought of two explosions; but there was only one, and the closer study of the curves convinced Galitzin that the second violent disturbance was due to the air wave (a rarefaction wave, it proved to be) striking and shaking the hill on which the observatory stands, in spite of the fact already mentioned that the air pressure did not vary much. The curves which Professor Turner exhibited showed first the slight microseismic tremor, then the earthquake waves on which the tremor was superposed (the microseismic embroidery soon becoming less marked, however), and afterwards the second, far more violent shock ascribed to the air-wave. Such an effect, Professor Turner added, had also been observed by Mr. J. J. Shaw. On the curves which Mr. Shaw subsequently showed, the microseisms and the other features mentioned could be plainly distinguished. Mr. Shaw had taken these observations in a dug-out of his own near his house in West

Bromwich, and he had made other experiments with two apparatus mounted 70 ft. apart, and later with a base of 2 miles; if a base of, say, 10 miles were available, he said, there should be a sufficient interval between the air-wave effects to settle that question. We may perhaps add that in the terrible Halifax explosion of 1917 the seismograms also suggested three explosions when there was probably only one, but the two additional shocks were hardly air-wave effects; we published a paragraph on the Halifax explosion on page 466 *ante*.

Professor Walker's report on "Seismology After the War" had nothing to do with the war, but urged international co-operation and a widespread distribution of observing stations. As regards the term "seismology," Professor Walker would prefer to class all the phenomena revealed by seismographs comprising microseisms and earthtides, and the cognate problems of the shape and distortion of the earth under the heading "geodynamics" which had been introduced by the Cambridge Committee. The most pressing problems appeared to him to be: (1) The investigation of time curves and earth tides and their interpretation, and (2) investigations in manifestly seismic regions. The instruments for the former investigations should not be placed in seismic regions and should be of the highest precision, particularly as to the vertical component which, as in terrestrial magnetism, was the discriminating factor. A good number of really efficient stations was desirable; in any case each of the great Dominions of the Empire should have its first-order station. For the second problem more numerous stations near seismic centres were required, but the instruments need not be of the highest precision. A central body was also necessary, and standardisation of the instruments was essential. For the present Galitzin's aperiodic pendulums with galvanometer registration seemed to be the best available, though even they did not give a precise reproduction of the earth tides and earth movements. Galitzin had recognised that and had, shortly before his death, devised a new apparatus for the direct measurement of the acceleration of the ground by means of the piezoelectric property of quartz; whether those instruments would answer for continuous seismometry, remained to be seen. The instruments should be strictly aperiodic. Professor Walker protested in this connection against the use of the term "dead-beat" in the place of aperiodic when large damping was all that was meant.

Gravity at Sea.

On behalf of the Committee upon "The Determination of Gravity at Sea" (chairman, Professor A. E. Love, F.R.S., of Oxford, secretary, Professor W. G. Duffield, D.Sc., of Reading), Dr. Duffield submitted a report consisting of three parts. When Dr. Duffield proceeded to Australia with the British Association in 1914, he was provided with three chief instruments, an aneroid barometer, a marine mercury barometer (both made by the Cambridge Scientific Instrument Company) and an enclosed mercury barometer, which had been given to him by Professor O. Hecker at Strasburg in June, 1914. In the Hecker instrument a volume of air is kept at constant volume and constant temperature; on board ship the barometer was suspended by cords from the ceiling of the refrigerator chamber in the water of a zinc tank. We commented, in our issue of October 13, 1916 (page 347), upon the severe difficulties of the observations and on the results obtained, chiefly with the first two instruments, on board the Ascanius and the Morea, during the outward and return journeys. This year's report dealt particularly with the difficulties and sources of error of Hecker's new method which Hecker himself had not yet been able to test. The conclusion at which Dr. Duffield arrived was that the method could be modified and could be made exact and would, in certain respects, offer advantages.

Both the other two parts of the report dealt with further possible sources of error. Dr. Duffield discussed "The Influence upon a Mercury Barometer of the Ship's Motion through Air." Both Hecker and himself, Dr. Duffield said, questioned the accuracy of a comparison between barometer readings taken in the harbour, on a ship at anchor, and at high seas, and when he was enabled to make observations on H.M. destroyer Plucky, a new cause of difficulty appeared, distinct from the ship's throbbings and vibrations. He mounted two marine barometers, one in the chart room underneath the bridge, the other in the ward room, the two rooms being considered the least and the most exposed to vibrations. When the boat was steaming at 22 knots in calm weather, the barometers kept steady within 1 microbar. But steaming against a west wind, itself at 20 knots to 25 knots, they observed considerable barometer fluctuations in the chart room, and much smaller fluctuations, but in the same sense, in the ward room. There was a suction effect, a fall of the barometer going west, and a rise going east (with the wind). The aneroid barometer, moreover, showed the same fluctuations. The effect seemed to be due to the eddies of the wind about the ship's hull; the closing of doors and port holes made no difference. The ward room was favourably situated with respect to these eddies, and the enclosed barometer would be more suitable for their study. It was rather surprising to see the barometer fall in the chart room at the rate of 1 mb. per minute as the ship turned about.

The third paper on "Corrections of Ship's Motion in Longitude," dealt with further experiment made upon the destroyer. A ship steaming east (west) is subject to an increase (decrease) of centrifugal force which would give rise to an apparent decrease (increase) of the value of gravity. Hecker observed that effect on the Black Sea, but Dr. Duffield was doubtful about the observations. During the trials the Plucky was run alternately east and west; the wind was from the south or south-west and did not exceed 10 knots; the records showed a rise of the mercury barometer when the boat was steaming east, and a fall when going west, the difference amounting to about 2 mb. The formula was $2\,\omega\,v\,.\,\cos\alpha\,.\,\sin\lambda$, where ω is the Earth's angular velocity, v the speed of the ship, λ the latitude and α the deviation of the ship's course from true north or south. Such a correction would also have to be borne in mind in meteorological observations, Dr. Duffield had already pointed out in 1916, since air currents are affected by it, and the war, he added, had drawn the attention of gunners to it. A shell fired east weighed less than if fired west, and if discharged at a horizontal velocity of 500 m. per second, to carry 8,000 yards, it would travel about 80 yards further (120 yards on the equator) when discharged in an easterly direction than in the opposite direction. Similarly, a 60-ton airship flying eastward at 60 knots could carry 100 lb. more than when flying westward.

Dr. Duffield also presented the report of the Committee on "The Solar Observatory of Australia." The report was merely formal; the time is not considered opportune to press for the erection of the buildings and the equipment of the observatory which is to be established at Canberra, the future capital of Australia, where the temporary buildings are standing.

Unsolved Problems of Canadian Weather.

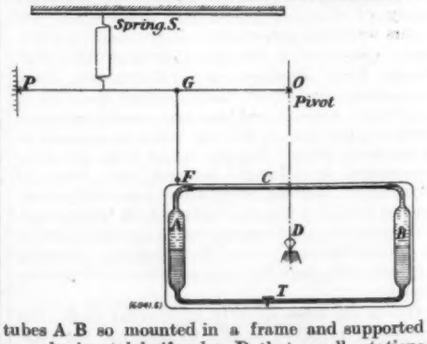
The only meteorological paper read was one by Sir Frederick Stupart, of the Canadian Weather Service, on "Some Unsolved Problems of Canadian Weather." He dealt with the climate of the Province of Alberta, the land east of the Rocky Mountains, about 750 miles long and 250 miles wide in the west-east direction, passing into the plains on the eastern side and separated from the Pacific by the ranges of the Rocky Mountains, the Selkirk and the Coast Ranges. The weather on that sloping plateau, 4,000 ft. and more above sea-level (Calgary, 4,200 ft.) was probably the most changeable on the globe, and the winters were particularly peculiar. The average temperature of January ranged between + 26 and − 18 deg. F. A cold winter went together with north-west winds and a high barometer in the Yukon and over the Great Lakes; in a mild winter the barometer was ¾ in. lower. The conditions in British Columbia (west of Alberta) were cyclonic, and winds from the west and south-west predominated, but the fall of temperature was observed in the plains before it affected the mountain stations. Sir Frederick suggested an influence of the ocean currents, the temperature of which was known to vary from year to year as observations in California and also in Alaska proved. But Sir Napier Shaw, opening the discussion, did not feel certain that the Mediterranean climate did not offer similar problems, and for him the chief problem was: What took place when a mountain range of, say, 10,000 ft. height was in the way of a stream of air; why did the stream get over as such, becoming colder and drier as it climbed up? He thought rather that the source of the disturbance was in the upper strata of the atmosphere, at 20,000 ft. height perhaps, and that we only saw the lower tail of the disturbance. Sir F. Stupart objected that the Alberta winters were always dry, and he considered that the rains of the district came from the Pacific, whilst Sir N. Shaw suggested the Gulf of Mexico as a source. Dr. A. Schuster concurred that further experimental investigations of air-current problems and of cyclonic conditions were very desirable, and a speaker from New Zealand added that the similar problems of the influence of the New Zealand Alps on the weather of the South Island were being investigated with promising results.

Determination of the Absolute Viscosities of Liquids at High Pressure.

In introducing this paper Dr. T. E. Stanton, F.R.S., stated that investigations had been in progress at the National Physical Laboratory on the relative lubricating values of a series of animal, vegetable and mineral oils in the special case in which the pressure between the surfaces was such that they were no longer separated by a film of oil, as they would be in the ordinary case of a well-lubricated journal bearing under moderate pressure. The apparatus used for this purpose had been the well-known Lanchester worm-gear testing machine in which the pressure between the teeth of the worm and worm wheel might be of the order of 2 tons or 3 tons per square inch. The efficiency of the gear was determined for each oil at a series of temperatures ranging from 20 deg. C. up to 75 deg. C.; the series of curves exhibited showed the variation of the efficiency with the viscosity of the oil. To render the comparison valid the values of the viscosities used in plotting the curves should evidently be those at the particular pressure of the oil in the gear, and as the variations of viscosity with pressure were not known, a special research was undertaken to determine the viscosities at high pressures.

The apparatus (illustrated by our diagram Fig. 7), which they had adopted for this purpose, seemed to offer some advantages over those of previous investigators from the points of simplicity and accuracy. The apparatus consisted of a closed circuit of

Fig. 7. Diagram of Apparatus for Determination of the Viscosities of Liquids under High Pressures.



tubes A B so mounted in a frame and supported on a horizontal knife-edge D that small rotations could take place in the vertical plane. The motion of the frame was constrained by the spiral spring S, and was measured by the movement of the pointer P over a finely-divided scale. The lower half of the circuit (a wide tube) was filled with mercury and the upper half (a capillary of glass or other material, 0·2 mm. to 0·6 mm. in diameter) with the liquid under test. In making an experiment the tap T was opened, and the reading of the pointer was taken after some considerable time had elapsed. The frame was then tilted so that the pointer moved

upward over a certain distance x on the scale. The tilting displaced the mercury; when the mercury had come to rest, the tap was closed, and the frame was tilted again until the pointer had its original reading. The difference of head in the two vertical limbs of the system tending to cause a flow of liquid round the circuit was calculated from the value of x and the dimensions of the link system GF. If the tap were now opened, the oil would be forced through the capillary under this pressure head, and if the spring were so designed that its deflection—due to the transfer of mercury from the right-hand vertical limb to the left limb—would keep the difference of head constant, the rate of movement of the pointer over the scale would be a measure of the quantity of oil passing through the capillary under the known pressure difference. The observations necessary for calculating the value of the kinematic viscosity μ/ρ of the oil under test were therefore determined.

An instrument on these lines had been designed by Mr. T. H. Hyde, of the Engineering Department of the Laboratory, and constructed in the workshop. As had been anticipated, considerable difficulties had been encountered in the construction of valves which would remain tight under the high pressures employed, up to 10 tons per square inch. These difficulties had been overcome and satisfactory results had been obtained; particulars of Mr. Hyde's results, Dr. Stanton concluded, would, it was hoped, be published on an early date. In reply to questions put by Professor A. W. Porter and Sir J. A. Ewing, Dr. Stanton added that the viscosity pressure curves did not at once indicate a steady rise at an increasing rate; there was first a slight decrease in the viscosity as pressure was put on. The pressure was put on in the evening and the experiments were continued the next morning. For observing at different temperatures, the whole apparatus was placed in a constant-temperature bath. Lord Rayleigh inquired about the tap, in which, Dr. Stanton explained, the double conical valves used tended to seal themselves.

Models of Crystals.

The 24 beautiful models of crystals, exhibited by Miss Nina Hosali, of University College, London, were designed by her to illustrate the possible crystal forms and their kinds of symmetry with reference to the crystallographic axes. Each model illustrates one of the 32 classes of symmetry; the shape of the glass envelope of a model is that of some simple crystal form, and within that envelope two (sometimes three) other forms are represented by means of coloured silk threads stretched over a framework of thin copper wires. Planes of symmetry are indicated by steel wires, axes of symmetry by white threads, and white beads mark centro-symmetry.

Mathematical Papers.

The few mathematical contributions submitted did not call for separate discussion in a mathematical sub-section. They were: "Report on Wave Motion," by Sir George Greenhill, a bulky memoir which is to be printed *in extenso* in the British Association Report; the Report of the Committee on the Calculation of Mathematical Tables (chairman, Professor M. J. M. Hill; secretary, Professor J. W. Nicholson); a paper by Professor A. R. Forsyth "On Gauss' Theorem for Quadrature and the Approximate Evaluation of Definite Integrals with Finite Limits," read by Professor A. N. Whitehead; and a paper by Professor H. Hilton, "On Certain Types of Plane Algebraic Curves."

(To be continued.)

NOTES.

Electricity Supply in Holland.

As a result of fuel shortage during the war the use of electricity in Holland has received a very considerable stimulus. In Amsterdam, for instance, it appears that, of 140,000 houses, no less than 110,000 are now provided with electric light, whereas, before the war, only 30,000 were connected. This large increase is accounted for by the fact that neither gas nor candles were available, so that the inhabitants could obtain no other form of light, and this led the Corporation to decide that every house should be provided with at least one electric lamp; the remaining houses are being connected at the rate of 500 a month. Electricity is largely used for domestic purposes other than lighting, as well as for industrial work. A new power station is now in operation on the north side of the River Y, and is already being extended. Three-phase current is generated at a pressure of 10,000 volts by means of steam turbines and water-tube boilers; some of the steam required is supplied by a refuse destructor. Similar developments are taking place throughout the whole of Holland, and in this development the State, the provincial governments, the municipalities and the communal authorities are all assisting. Considerable progress has already been made towards the co-ordination of the various supply systems, the work being largely facilitated by the fact that the frequency is already standardised at 50 cycles. The supply stations have been, or are being, interconnected to facilitate generation by large units in suitable situations. Distribution is effected, usually, by overhead wires, for which purpose the supply authorities possess compulsory wayleave powers. This enables the needs of rural districts to be catered for, as well as those of towns and industrial areas, and considerably facilitates the use of electricity in agriculture. The installation of electric pumps to replace the numerous windmills used for land drainage is now becoming general and will soon effect a notable change in the appearance of the Dutch landscape. These, at all events, are the impressions gained by a deputation representing the Institution of Electrical Engineers, who recently visited Holland at the invitation of the Society of Directors of Electricity Works in the Netherlands. The deputation points out that the rapid developments above referred to will call for considerable extensions of generating plant and distribution systems, and, as the development of electrical manufacturing industries in Holland is proceeding at a less rapid rate, an excellent opening exists for British manufacturers to extend their business with Holland. Except in the matter of cables, British electrical goods have not been largely used in Holland, the generating plant and motor equipment having been generally supplied by German or Swiss manufacturers. We trust that a determined effort will be made to remedy this state of affairs in the near future.

Progress in Shipbuilding.

There is evidence that the shipbuilding industry is developing satisfactorily. Certainly there is plenty of work to do, and all that is needed is an increased determination on the part of all to ensure the maximum output, since this is a primary necessity for the re-establishment of industry generally. During the last quarter, according to Lloyd's Returns, 182 vessels, aggregating 713,927 tons, were commenced; while 162 vessels, aggregating 416,045 tons, were launched. The former figure is about 53,000 tons more than in the previous quarter, but the latter is 112,000 tons less. This should not be regarded seriously, as the date of launch is incidental and does not indicate progress accurately. In nine months the tonnage launched totalled 1,124,270 tons. The work actually in hand is over 290,000 tons greater than at the end of the June quarter. One notable feature is that the ships ordered are of greater size. The number of vessels on hand is almost exactly the same, 781 now as against 782 three months ago, while the tonnage is much higher, 2,816,773 tons as compared with 2,524,050 tons. We are dealing only with merchant ships. There is considerably more work on hand in this country than at any previous period in the history of shipbuilding. The highest point was reached in March, 1913, when the total tonnage was just over 2,050,000 tons; it dropped then to 2,000,000 tons at the end of June of the same year, since when there was a steady decline until this year. Ten years ago the total was as low as 800,000 tons. The figures, showing the enormous amount of work now in hand as compared with previous periods, indicate the confidence of British shipowners. We have remarked that the tendency is towards the building of large ships, and in this connection it may be noted that there are 14 more ships exceeding 10,000 tons building now than was the case three months ago, there being now six vessels between 10,000 tons and 12,000 tons, 18 between 12,000 tons and 15,000 tons, 14 between 15,000 tons and 20,000 tons, and 4 between 20,000 tons and 25,000 tons. A notable feature is the advance in merchant shipping in the Barrow district, the total having doubled during the three months, being now seven vessels of 55,295 tons aggregate. At Belfast the total is 2½ per cent. less than three months ago, but still highly satisfactory—37 vessels of 312,350 tons. There is a large increase at Glasgow, equal to 17 per cent., as compared with three months ago, there being on the stocks in the upper reaches of the Clyde 171 vessels of 642,053 tons. In the lower reaches, however, the total is practically the same, being 350,245 tons. This also applies to a comparison in the case of the Hartlepool district, where the total is 77,320 tons; but at Hull, due to the increase in the building of trawlers, the total is over 25 per cent. higher, being 66,821 tons. At Liverpool there is also an advance, reflecting, as in the case of Barrow, a change over from war to merchant work, the increase on three months being 23 per cent. The total now on hand is 72,025 tons. The increase in Middlesbrough is at the rate of 40 per cent. as compared with three months ago, the tonnage on hand there being 227,565 tons. Newcastle shows a favourable result, although not so great as in other districts, the tonnage there being 536,960 tons, an addition equal to 8 per cent.; while Sunderland, where there is also a fair increase, equal to 6½ per cent., has 286,390 tons. Glancing at the state of trade in other countries, a decrease in the American figures is notable. Instead of 994 vessels there are only 767 now building, the tonnage of these being 3,470,748 tons as compared with 3,874,143 tons three months ago; the greater part of the decrease is on the Atlantic and Pacific coasts. There has also been a decrease in Canada, the tonnage now being 308,465 tons as compared with 346,453 tons three months ago; but in this case the decrease is due to work on the Great Lakes. Most of the other countries have increased the volume of work on hand. In the case of Denmark the tonnage has gone up from 57,771 tons to 68,074 tons. France has shown a large recovery from war conditions, as 64 vessels are now being built as against 38, the tonnage being 174,736 tons as compared with 109,615 tons. In the case of Holland there has been an increase from 219,233 tons to 288,042 tons. Japan has only one additional ship in hand, but the tonnage is up by 17,600 tons, the total now being 299,600 tons. Norway, however, shows a large rate of increase, the tonnage having gone up from 62,441 tons at the end of June to 83,941 tons at the end of September. Sweden shows an increase of 4,000 tons. In Spain there is a decrease, the tonnage of vessels building (90,705 tons) being 28,000 tons less than three months ago.

Deficit of the Hohenlohe Works.—The balance-sheet for the last financial year shows a loss of 6,010,825 marks, as compared with a profit of about 6,600,000 marks for the preceding year, when a dividend of 8 per cent. was paid. The first seven months of last year were satisfactory, and gave promise of a similar dividend to that distributed for the preceding year, but the events of the last five months, beginning with November, completely altered the situation. In the hope that matters would improve and normal conditions return, various extensions in hand were proceeded with.

The late Mr. William Kirtley.—We regret to have to record the death, in his seventy-ninth year, of Mr. William Kirtley, of 31, Larkhall Rise, Clapham. Mr. Kirtley became a member of the Institution of Civil Engineers in March, 1875, being at the time on the staff of the London, Chatham and Dover Railway, Longhedge Works, Wandsworth. He served a pupilage of six years, from 1854 to 1860, under Mr. Mathew Kirtley, locomotive superintendent of the Midland Railway Company. Afterwards, he acted for nine months as assistant to Mr. Charles Markham, then in charge of the out-door arrangements for the working of the trains for the same company. Then, and for about three years, from November, 1861, to February, 1864, he was running foreman in the Locomotive Department, in the London district of the Midland Railway Company. For the following ten years, 1864 to 1874, Mr. Kirtley was superintendent of the locomotive works, Derby, and of all the repairing shops at the out stations of the Midland Railway Company. In April, 1874, he was appointed locomotive, carriage and marine superintendent to the London, Chatham and Dover Railway Company. He retired from active business several years ago.

LITERATURE.

Cotton Spinning. By William Scott Taggart, M.I.Mech.E. Vol. I. Including all processes up to the end of Carding. Illustrated. Sixth Edition. London: Macmillan and Co. [Price 7*s.* 6*d.* net.]

More than twenty years have elapsed since Mr. Scott Taggart began to instruct students and the public in the technics of cotton spinning. At that time the literature of the subject was comparatively small, and he regretted that cotton spinning had never occupied the prominent position to which it was entitled by reason of the ingenuity exhibited in solving the mechanical problems presented and the unquestioned usefulness of the result. He himself has done much to attract attention to the scientific and economical importance of the industry, for this is the sixth edition of a pioneer work that has acquired the position of a standard book of reference on cotton spinning. Naturally, the treatise has grown in the process, the present volume carries the reader no further than the carding process, a necessary preliminary to the real task of cotton spinning. This division of the subject into three volumes indicates the thoroughness of the supervision of the mechanics of the whole industry, for the treatment is conducted in regular sequence as the various operations unfold themselves. The work is historical as well as technical. The introduction of each fundamental improvement is duly noted. The reason for the disappearance of absolute methods is explained, and the devices that led to the adoption of improved technique clearly traced. The illustrations assist the letterpress admirably, and at critical points in the description, enlarged diagrams are introduced to make the details better apprehended.

One turns, naturally, to the preface to learn the character and the extent of the additions that have been found necessary, owing to the progress of the last quarter of a century, and it is not a little startling to note, that the anxiety everywhere expressed to-day regarding the nation's economic stability and active power of competition, found urgent utterance from a competent authority, when evils were less imminent and proposed remedies less drastic. A comparison of the past position with the future outlook may suggest a gleam of much-needed hopefulness. As far back as 1895, the author wrote: "It cannot be denied that at present we are passing through a very severe crisis, and unless something is done to keep apace of the enormous strides other countries are taking, and which enable them to compete successfully with our own products, we shall find ourselves lagging behind and losing the advantages we have hitherto possessed." We do not remember, nor do we care to inquire, what was the particular crisis, whether, acute or chronic that menaced the industry at that time, but as the country weathered the hostile conjuncture of circumstances, we may hope that in the severer issues of to-day an equally happy escape will be found from the perils that beset us. The sentence quoted might have been written to-day, and one would like to ask the author whether there was ever a time in his long experience, when such words were not appropriate to the condition of the country, or whether the minds of manufacturers have not always regarded the future with some dread and misgiving. We are not disputing the gravity of the apprehension felt long ago, but we may regret that the gravity of the past situation did not compel the adoption of more adequate means, as protection against the perils of to-day, that threaten to undermine the position acquired by industry, intelligence and enterprise.

The remedies suggested now to safeguard a graver situation than the author could have imagined at the end of the last century, wear a somewhat antiquated appearance. Then, as now, the shortcomings of our educational system were criticised and improvement demanded, and the necessity for more and better technical education was urged. The term "scientific research" was not, perhaps, so much in men's mouths then, but the insistence "on increased facilities for reasoning" and the provision of "opportunities for the development of ingenuity" cover much the same ground, and uggest that the new armoury contains little that was not found in the old. The clamour for scientific research now may have as little awakening effect as that for technical education in the past, for already there is a danger lest the cry should become a catchword that everyone eagerly repeats, as an open sesame to the road to success, while the few only who have sufficient knowledge to understand what it means, and what it can accomplish, may lack the influence to direct its steps on the right path. Another section, adopting narrow selfish views, will be disappointed if research does not affect production in such a manner, that progress will be evidenced by satisfying the double test of decreasing the cost of goods made, and of increasing the wages of those who make them.

There is little necessity to pass in review the contents of a book so well known. To a short historical account of the industry, detailing the improvements successively introduced into machinery specially designed for cotton spinning, follows a chapter on the cotton growth and fibre describing the variations in length of staple, the varieties due to seed and place of origin, the effects of cultivation in modifying the character of the product and the necessity of watchfulness for signs of deterioration in the output. The form of the elongated cell and the effect of "twist" in the subsequent spinning are treated more fully. Mr. Scott Taggart was one of the first to call attention to some of the more glaring errors that have circulated concerning the cotton fibre, and the ill effects of ignorance may still be traced in the rough and ready methods of sampling in use by the expert. In this work, some further cogent criticism is offered, but relegated to an appendix, where its importance may not be justly estimated. Careful breeding and the selection of pure strains, are producing a lint of superior quality, but recklessness in mixing seeds, combined with ignorance and greed on the part of the growers is working much evil. A sound and instructed public opinion is necessary to ensure intelligent administration in the management of cotton plantations, and the author's contribution to this end is valuable. Greater enlightenment, too, is needed by the examining class of experts, who, from unfamiliarity with the produce of a pure strain, may reject as worthless a sample that has been carefully nursed for special spinning purposes. In recent years, much light has been thrown on the puzzling problems connected with the action of environment on the properties of the fibre during maturation, and delicate machinery has been invented to demonstrate the infinitesimal differences which should be taken into account in classifying lint cotton. Rigorous scientific tests can now be substituted for the haphazard methods that have long been in vogue.

Ginning is the first mechanical process to which the boll, as received from the cotton grower, is submitted, and as this operation is necessarily performed abroad, the evolution of the machinery has attracted little attention in this country. Descriptions of three typical gins, the knife roller, the Macarthy, and the saw-gin are given, which suffice to explain the operation. Bale breakers for loosening the hard-matted cakes of cotton, formed by the heavy hydraulic pressure put upon the bales in order to reduce the bulk and facilitate conveyance, are fully illustrated and explained in the following chapter. The handling of the roughly-broken masses requires graduated machinery, that removes impurities, easily detected at first, but gradually diminishing in size, are less easily detected, till finally, we are introduced to the scutcher that eliminates the foreign matter, and the defects that the openers and the beaters have failed to expel. Orderly progress towards perfection is well marked, and the work of a cotton mill in its initial processes can be followed by ordinary intelligence. The illustrations are clear and excellent, and wisely, the details are not allowed to obscure the general principles. The author assumes very little knowledge on the part of the reader, and there is internal evidence to show that he has a very poor opinion of the students' mathematical acquirements. Perhaps the author is justified by his experience.

The last and most important chapter in the book is devoted to carding, so that in this volume the details of spinning properly so called, are not touched. The story is carried no further than the preparation and cleaning of the material, for the object of carding is to continue the removal of the imperfections left untouched by the previous machinery. The evident and heavy impurities have disappeared, but the short and stained fibres have still to be removed, the entangled mass has to be unravelled, and the orderly arrangement of the fibres effected with the least possible waste. Several carding machines are described, which illustrate the improvements that time and ingenuity have worked, but the revolving flat card which has practically displaced all others, naturally receives the greatest attention. The account ought to prove very interesting, for at every stage of the process some remarkable instance of mechanical ingenuity is encountered. Where so much is well done, it seems ungracious to raise any objection, but the addition of an appendix is not the most convenient way of supplying information concerning improvements in machinery, introduced since the publication of earlier editions. Moreover, the appendix is not well arranged; the order maintained is not that of the text, and references to the new matter in the appendix are frequently wanting. The addition of 60 pages is a formidable adjunct, and one might ask Mr. Taggart to consider whether the contents of the appendix might not more appropriately be incorporated in the text.

The Elements of Wood Ship Construction. By W. H. Curtis. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited, 6 and 8, Bouverie-street, E.C.

Among the many interesting developments arising directly from the war the revival of the art of wood ship construction occupies a prominent place. The importance of the task of replacing the loss of shipping caused by the submarine warfare and by the other war risks was such that all means for increasing the amount of new tonnage were welcomed, and the ancient art of wood ship construction received an impetus such as no one could have foreseen. To some extent the construction of wooden ships had been carried on in America previous to the war, and this fact together with the splendid local supplies of timber, suitable for the purpose of shipbuilding naturally led to an enormous development of the industry in America. This sudden expansion of the industry found the numbers of skilled carpenters available altogether insufficient and the book now under review forms part of the scheme of education and training prepared for the United States Shipping Board Emergency Fleet Corporation to assist in the training of men for the work of wood ship building. The scope of the volume is such that it embraces the practical details of construction from the laying of the keel blocks to the completion of the vessel on the stocks, including the construction of deckhouses, skylights and other items of joiner work.

Keels, sterns and stern posts provide the subject matter for the first chapter and the construction of these for various types of vessel are described and illustrated in detail. Preparation of the building slip, erection and declivity of keel blocks and erection of keel on the blocks form the introduction to this chapter and provide the student with an adequate conception of the work which has to be done on the slip preparatory to commencing the actual erection of the vessel. The arrangement shown of the method of fitting wedge block and wedges under the keel would seem to be inferior to the better known method of using only two large broad wedges bearing directly on the keel and on each other. Details of keel scarphs and of the methods of connecting stems and stern and rudder posts to the keel are described and illustrated, and are followed by a detailed description and illustrations of the methods of making and building up stems, sternposts and rudder posts. These present no novel features but are typical of the practice for the types chosen.

Chapter II deals with frames; ordinary transverse, cant, and stern frames being bu lt with in detail and methods of building, erection and fairing are described. Chapter III deals with inboard hull details such as keelsons, clamps and shelves, deck beams, and beam knees, ceiling, bulkheads, hold stanchions, &c., while Chapter IV deals with

the remaining inboard hull items such as hatch coamings and framing, breast hooks, waterways and decking, mast partners, &c. Hull planking, erections, rails, mast wedging, &c., are dealt with in Chapter V along with many details of joiner work in connection with the building of deck houses, doors, windows, &c. Each item has been dealt with in a thoroughly capable manner, the descriptive matter being amplified by numerous excellent and well-chosen illustrations, the whole forming a very complete record of modern practice.

Excellent features in the arrangement of the volume are the glossaries of technical terms and the forewords to Chapters II to IV. The tabulation of the main and coincident operations contained in these latter should be of considerable assistance to the student in giving him an indication of the sequence of the building operations, and thus a more intelligent interest in the details of individual items. With the passing of the submarine menace it seems likely that the wood shipbuilding industry will once more sink to its pre-war dimensions, but the revival has not been without interest to the student of naval architecture, and a comparison between the volume now under review and the "Naval Architecture" of the late Dr. S. J. P. Thearle, published in 1874, shows that progress during the intervening years has been extremely slow.

WIRELESS DIRECTION FINDERS.*

By Captain H. RIALL SANKEY, C.B., R.E.

THE subject of wireless telegraphy is now so vast that a general review would be neither interesting nor instructive, and therefore, and in view of the fact that this lecture is given at a shipping exhibition, I have selected as subject-matter a special use of "wireless" which has received its major development during the war, and until recently has been kept a jealously-guarded secret, in respect of its application for war purposes. It was one of the things which materially assisted the silent Navy and the British Tommy to win the war, and which is now available for the use of the shipping industry. By its use a ship can at any time ascertain its position.

Historical.—A complete historical survey would occupy too much time, and I can only refer to a few stages in the development of the apparatus. Fig. 1 illustrates an early pattern of direction finder known as the Marconi-Bellini-Tosi radiogoniometer. This instrument was used in conjunction with open aerials, and relied upon mechanically-operated balanced electrical capacities or condensers. It was regarded as a very remarkable piece of apparatus at the time of its introduction, and a number were installed. An important advance was made when the Marconi Company adopted the closed aerial circuit, now in general use, and replaced the mechanically-balanced capacities by independent condensers capable of exact balance.

A great increase in range followed the introduction of the Marconi-Round receiving valve in 1913–14, after which the direction finder came into prominence as an instrument of war. In January, 1915, Captain Round and Lieutenant Tremellyn established experimental military direction-finding stations at St. Omar and Abbeville which were destined to be the forerunners of a very large number of similar stations.

I was present at the original tests of these stations, and can vouch for the remarkable results obtained. We were able to ascertain the direction of known wireless stations within a degree or two, and were able to locate many German military wireless stations. From this beginning rapid strides have been made, both as regards accuracy and range, and during the last four years the wireless direction finder has been put to special uses peculiar to a state of war, and in this sphere it has abundantly proved its value. Its practicability has been established, the degree of accuracy attainable in practice has been ascertained, as well as the limitations of the various types. It has been very effectively "tried out," notably at the war stations installed by the Marconi Company, where it was in constant use day and night until the cessation of hostilities, and as a result an accumulated fund of information based on actual working is now available.

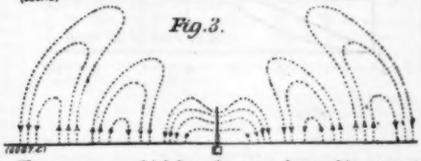
In the hands of the British the direction finder was of value in guiding aircraft and in locating enemy wireless installations on land, at sea and in the air. A number of special stations, as referred to above, were erected at selected points on the coast and elsewhere, and these worked in pairs or in groups. The individual stations of a group observed, at the same moment, the direction of a particular moving enemy station and reported immediately to headquarters, where, by means of a chart, the observations were combined and the position of the enemy ascertained at once. The whole operation required but a few minutes. Fig. 2 shows the location of such of these stations as are now open for public service. The German warships, submarines and Zeppelins were invariably equipped with wireless, which was used somewhat freely. It was thus possible to follow them up pretty closely, and much valuable information was gained in this manner.

* Lecture at the Olympia Exhibition, October 9, 1919.

In its application to the practical problems of marine and aerial navigation the wireless direction finder has been used in two distinct ways. In fact, it may be said that up to the present time there has existed two schools of thought, one of which would have the direction-finding stations on the ground in fixed positions, while the other would have them in the ship or aircraft. The British have used both methods for ship and for aerial navigation. The Germans, on the other hand, appear to have relied upon fixed direction-finding stations placed on the islands off their coast and in occupied territory, for directing their Zeppelins as well as surface craft and submarines. From the military point of view our war system of aerial navigation possessed an obvious advantage since it enabled a ship or an aeroplane to ascertain its position unknown to the enemy and without advising him of its whereabouts.

FIG. 1.

Fig. 2.
NORTH SEA
ATLANTIC OCEAN
SCOTLAND
IRELAND
ENGLAND
FRANCE
ST GEORGE'S CHANNEL
ENGLISH CHANNEL
• Stations open for Ship and Shore Communication.
○ Admiralty and Private Stations Open for Communication with certain Classes of Ships only
• Stations which Communicate with Ships of the Mercantile Marine in case of distress.
• High Power Restricted Public Service Stations.



The arguments which have been put forward in support of the fixed-station system may be summarised under two headings as follows:—

1. Fixed direction-finding stations are not limited in regard to the size of aerial that may be employed; hence they may be made of such sensitiveness as to be able to ascertain the direction of ships and aircraft fitted with low-power transmitters even when the ranges are measured in hundreds of miles.

2. Direction-finding gear should be under the care of highly-trained *personnel*, and as the number of fixed stations required is relatively small, highly-skilled specialist operators can be employed and the stations kept continuously under expert supervision.

Until recently the first argument was perfectly sound, but the advent of the three electrode valve and its successful application to the problem of the reception of wireless signals has resulted in the production of a detector of extreme sensitiveness by means of which enormously increased ranges are obtained, and very much smaller aerials can be used and can be erected on the average ship. Under such conditions the detector will pick up signals from another ship or from a standard low-power shore station 500 miles away—a distance very much in excess of that necessary for ordinary direction-finding work. Extremely large aerials, therefore, are no longer necessary. To obviate the need of the highly-skilled *personnel* referred to in argument 2, a new and greatly simplified pattern of direction finder has been developed by the Marconi Company, which I propose to describe later.

The objections to the fixed-station method relate entirely to the practical working of the system. A ship or aeroplane without direction-finding gear, when wishing to ascertain its position must call up the fixed direction-finding stations within range, await an acknowledgment, and possibly wait its turn before sending out repeatedly the prearranged signal, by means of which the land stations are able to ascertain its position. There will then be an interval while the bearings are communicated by ordinary telegraph or telephone to the controlling station, and the ship's position worked out, after which the ship is advised by wireless of its position, and the message acknowledged. The German method already referred to was a modification of this method, in which wireless only was used. It served its purpose, but it must be remembered that at the time there was practically no commercial traffic and jamming among the German stations was made impossible by an extremely rigid central control, which would be undesirable, if not impossible, under peace conditions.

In view of the great increase in wireless traffic with ships and the growth of traffic with aircraft which will assuredly take place in the future, any system of working which involves prolonged signalling is clearly at a disadvantage. Apart from the question of jamming, the actual time during which the transmitting gear is commercially inoperative must be taken into consideration when traffic is heavy, as it very well may be at the time when directional readings are required.

If, however, the direction-finding apparatus is on the ship, the operator can take bearings by merely listening on the direction finder and noting the direction of known stations which happen to be working at the moment. Ships and aircraft carrying their own direction-finding gear can therefore ascertain their position without interfering in any way with the normal wireless traffic in busy times. When traffic is light any desired station may be called up and its direction ascertained from the signals sent in reply.

Technical.—I now propose to describe briefly the principle of the wireless direction finder, but before doing so it will be necessary to devote a few moments for the benefit of those members of the audience who may not be familiar with the subject, to forming a clear idea of what is meant by a wireless wave, and how such waves convey energy from the transmitter to the receiver.

We are all familiar with the fact that a stone dropped in a smooth pond causes a series of ripples which travel outward in concentric circular rings and are capable of setting in motion, let us say, a fisherman's float in some remote corner of the pond. In this case the stone is the transmitter of energy, the float is the receiver and water is the medium of transmission. A moment's consideration will convince that the first half of each ripple (or wave, as we say in wireless) causes an upward motion of the float and the last half a downward motion. In wireless telegraphy and telephony the medium is the all-pervading ether of space in which we set up waves by electrical means and from which we receive energy in an analogous manner.

In Fig. 3, annexed, an endeavour is made to represent diagrammatically a series of waves leaving a transmitting aerial. The curved lines indicate an abnormal condition of the ether corresponding to the abnormal condition of the water surface in our smooth pond analogy. These abnormal regions, regions of ether strain, or wireless waves, surround the transmitting aerial in much the same way as the stone was surrounded by the ripples, but they move outwards very much more rapidly, the speed of propagation being equal to the velocity of light—185,000 miles per second. They reach the receiving aerial therefore, almost instantaneously, and their electrical effect upon this aerial is closely analogous to the mechanical effect of the water waves upon the fisherman's float—briefly, the first half of a wave causes an upward current in the aerial and the second half a downward current.

Let us now see how these principles can be applied to the problem of direction finding. If we have two conductors, or "aerials" fairly close together, both receiving electric waves from the same source, it is easy to realise that by moving one aerial in relation to the other we can form an idea as to the direction of the wireless station from which the waves are emanating. (Fig. 4.) If two such aerials be placed one behind the other with respect to the transmitting station, the currents in one will always be a little later than those in the other. On the other hand, if the aerials are side by side, i.e., at an equal distance from the transmitting station, they will be struck at the same instant by each wave as it sweeps past, and there will be no difference in time between the two currents. In intermediate positions we shall obtain intermediate results.

The means of comparison is simple. (Fig. 5.) The two aerials are connected together at their upper and lower ends so as to form one aerial, shaped as a rectangle or triangle, and in the lower limbs a receiver is coupled. In this position the receiver responds to the difference between the currents in the vertical limbs which we have so far regarded as separate aerials.

When the horizontal limb is set at right angles to the direction of the transmitting station no signals will be heard, since the current in the vertical sides of the rectangle, or the sloping sides of the triangle are exactly equal and annul each other. As the aerial is twisted round so that one limb comes nearer the source of the waves, and the other becomes more remote, the signals increase in strength until a maximum is reached, when the rectangle or triangle points towards the transmitting station.

If it were practicable, therefore, we might use for

direction finding a large movable aerial of this kind, but it is a *sine qua non* that the directional reading shall be taken with rapidity, hence, if for no other reason, large and unwieldy movable aerials cannot be used. (Fig. 6.) Movable aerials of a size that may be conveniently controlled are unsuitable for other reasons, as will be shown later, so that this apparently simple method is applicable only to the few special cases in which the approximate results obtainable by means of very small frame aerials will suffice.

In the system which is coming into general use (Fig. 7) two independent triangular or rectangular fixed aerials are erected with their planes at right angles and connected to an instrument which may be said to reproduce the external conditions in a small space and, as it were, in a concentrated form. A "search coil" of quite small dimensions which is within the instrument, may be regarded as a diminutive direction-finding aerial under the influence of the large fixed aerials. (Fig. 8.) Rotation of the coil is equivalent to the rotation of a large aerial, but its size and weight is such that it can be manipulated in the convenient manner necessary for quick and accurate work.

Before proceeding to describe the apparatus used in modern direction finding I wish to give reasons for the statement I have just made regarding the unsuitability of very small-frame aerials for this purpose. They are as follows :—

1. In all directional aerials the directional effect is diluted more or less by a non-directional component, and in very small aerials the directional effect is seriously masked by this non-directional component.

2. With very small aerials enormous amplification of signals must be resorted to, and as a result further dilution takes place owing to an appreciable proportion of the energy being received directly upon the connecting leads and receiving gear. (Figs. 9 and 10.)

These are two causes of what we have called "dilution of the directional effect" in small-frame aerials, and it will be readily appreciated without further explanation that the effectiveness of such aerials as direction finders is of no high order. I will go further, however, and will show you that this dilution of the directional effect is worse than would appear at first sight. It not only masks the phenomena we are depending on, but it actually distorts the readings and alters the relative positions for minimum and maximum signal strengths. In order to illustrate this point I will refer to Figs. 11, 12 and 13.

In Fig. 11, I have drawn three curves—A, which represents the current which would be received by an aerial having directional properties only, B representing the diluting current due to the non-directional component and to the direct reception by the connecting leads and gear, and C, which is the algebraic sum, *i.e.*, the resultant of A and B.

It will be seen that the effect of B is to increase one maximum while decreasing the other and to distort both minima.

In Fig. 12 the curves A and C are set out on a polar diagram which very clearly illustrates the distortion effect. In this diagram we have, for the sake of clearness, omitted any reference to difference in phase between what we may call the directional currents and the diluting currents. Such a phase difference exists in practice with the result that the minima becomes vague and ill-defined, and the diagram assumes the thoroughly unsatisfactory shape indicated in Fig. 13.

(To be continued.)

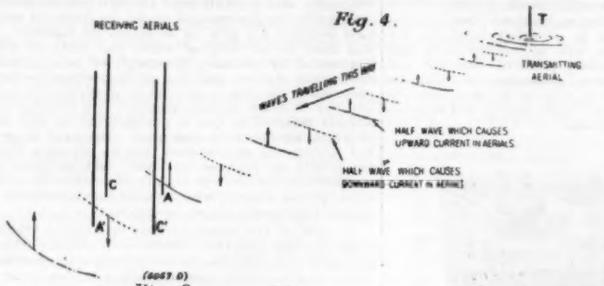
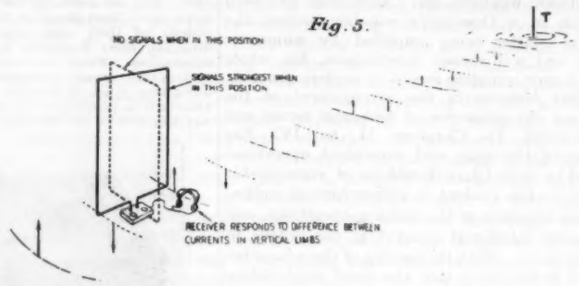


Fig. 4.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NO SIGNALS WHEN IN THIS POSITION
SIGNALS STRONGEST WHEN IN THIS POSITION
RECEIVER RESPONDS TO DIFFERENCE BETWEEN CURRENTS IN VERTICAL LIMBS

Fig. 5.

Fig. 6.

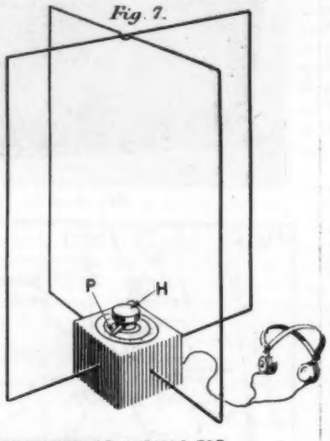


Fig. 7.

Fig. 8.

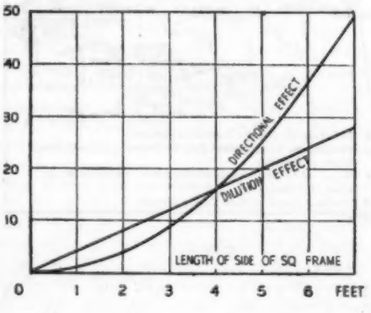
Fig. 9. RECTANGULAR FRAME AERIALS FOR DIRECTION FINDING.

TABLE SHOWING THE EFFECT OF SIZE OF FRAME ON THE RATIO OF DIRECTIONAL EFFECT TO DILUTION EFFECT ON THE ASSUMPTION THAT THESE EFFECTS ARE EQUAL IN THE CASE OF A 4-FOOT FRAME

SIZE OF FRAME	DIRECTIONAL EFFECT	DILUTION EFFECT	DIRECTIONAL EFFECT / DILUTION EFFECT
6 x 6'	¼	2	1/8
1 x 1'	1	4	¼
2 x 2'	4	8	½
4 x 4'	16	16	1
8 x 8'	64	32	2
20'x20'	400	80	5
70'x70'	4900	280	17·5

Fig. 10. RECTANGULAR AERIALS FOR DIRECTION FINDING.

CURVES SHOWING RELATION BETWEEN DIRECTIONAL EFFECT AND DILUTION EFFECT IN SMALL FRAMES



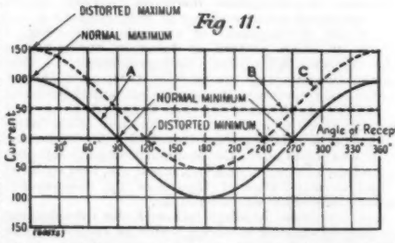


Fig. 11.

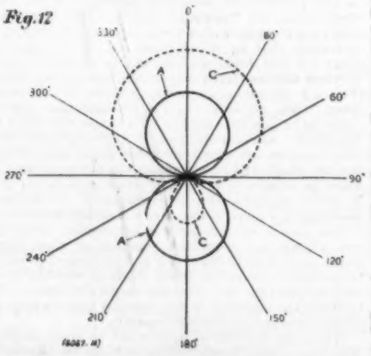


Fig. 12.

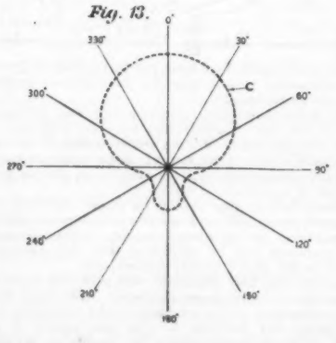


Fig. 13.

BRADFORD ENGINEERING SOCIETY.—With the new session now commencing the Bradford Engineering Society celebrates its "coming of age." The society is carrying on an important work, and its success is shown by the fact that the membership now reaches nearly 300, so that it has become one of the largest of the provincial societies devoted to engineering. The question of fuel economy and coal conservation is of vital importance at the present time, and in arranging the lecture syllabus for the present session, special prominence has been given to the various methods by which this object may be attained.

THE THREE-ELECTRODE THERMIONIC VALVE AS ALTERNATING CURRENT GENERATOR.*

By Professor C. L. FORTESCUE.

(*Concluded from page* 493.)

(3) *Theory of the Combination of Valve and Capacity-Inductance Circuit.*—In designing the valve and circuit two things have to be kept in mind. In the first place the conditions must always be such that any incipient oscillation in the capacity-inductance circuit will cause sufficient power to be supplied from the valve for the oscillation to be built up from the indefinitely small initial values to relatively large amplitude. In the second place, the circuit arrangements should be such that the maximum power is taken from the tube, so setting up an oscillation of the greatest possible amplitude; in which connection it may be remarked that with bad proportioning of the circuit and the valve the current generated may reach a stable maximum value long before the possible maximum power output from the tube is attained. But design of this kind is obviously wasteful, as it leads to the use of unnecessarily large and expensive valves.

Referring to the simple circuit arrangement of Fig. 6, page 492, it will be seen that in the course of the cycle of the oscillating current in the capacity-inductance circuit, the effective voltages both between the grid and the filament and between the positive electrode and the filament are varying. In Fig. 9 the variation of these two voltages is plotted for one cycle in the correct relative phases to the current in the inductance; the positive direction of the current in the inductance being from the point *a* to the point O, and on to the point *b* (Fig. 6). With regard to the tube the positive directions for the voltages at both the positive electrode and the grid is when the filament is negative. In order to determine the nature of the current in the part O *b* of the inductance L it is necessary to refer to the characteristics of the valves. These may be plotted as in Fig. 5, page 492, but are preferably drawn out as in Fig. 10, a method adopted in H.M.S. Vernon in 1915. In this figure the voltage at the grid is plotted horizontally, the voltage at the positive electrode vertically and the current at the positive electrode is drawn in as a series of contours of constant current.

The first point of the cycle of Fig. 9 is a point where the voltage at the grid is a maximum and that at the positive electrode a minimum. This will correspond to a point P in Fig. 10. After one quarter of a cycle has been passed through the voltage at both the grid and the positive electrode will be at the normal values as maintained by the batteries. This state corresponds to the point X of Fig. 10 (which also corresponds to the point X of Fig. 5). After one-half cycle has been passed through the point Q of Fig. 10 will have been reached. After three-quarters of a cycle a return is made to the point X; and back again to the point P on completion of the whole cycle. Since the alternating components of the voltages in Fig. 9 differ in phase by 180 deg., the points P, X and Q of Fig. 10 will lie on a straight line, which has been called the "Oscillation Line." The way in which this line cuts the contours in Fig. 10 shows the variation of the current in the part O *b* of the inductance L. This variation has been plotted in Fig. 11 in its correct phase relation to the current in the inductance. It will be seen from an inspection of the second curves of Figs. 9 and 11 that the alternating component of the current flowing in at O and out at *b* (Fig. 6) is opposite in phase to the alternating component of the voltage between these two points. The conditions chosen for the diagrams represent, therefore, a supply of alternating power to the inductance. Had the oscillation line been drawn as in Fig. 12, the phase of the current would have been reversed, and power would have been abstracted from the circuit. One condition necessary for the building up of a small incipient oscillation is therefore that the oscillation line should lie as in Fig. 10 and not as in Fig. 12. Another condition is that the alternating power supplied to the circuit should exceed the sum of the power expended in the circuit and the power abstracted from the circuit (by any means whatever). The power expended in the circuit is due to the main oscillating current in the inductance and the condenser and to the exciting valve current in the part O *b* of the inductance. With the simple circuit the power abstracted is only that required to vary the voltage of the grid; observing that the grid current is usually in phase with the alternating current voltage across the part *a* O of the inductance.

As a very good first approximation, which is good enough for most designing purposes, the following assumptions may be made:—

(*a*) The power expenditure arising from the passage of the exciting current from the valve through the part O *b* of the inductance may be neglected in comparison with the whole loss due to the main oscillating current.

(*b*) The power abstracted from the circuit to operate the grid may be neglected in comparison with the loss due to the main oscillating current.

(*c*) The resistance component of the voltage across each part of the inductance may be neglected in comparison with the reactance component, i.e., the relative phases of the voltage and current may be taken as differing negligibly from 90 deg.

(*d*) The amplitude of the incipient oscillation may be assumed to be so small that the characteristic curves may be taken as straight lines over the whole range under consideration.

With these assumptions the conditions necessary for the maintenance of oscillations can be calculated easily. Let δ I be the R.M.S. value of the incipient alternating current in the inductance. The corresponding R.M.S. voltage, δ V, across the whole inductance is

$$\delta V = L \omega . \delta I \quad . \quad . \quad . \quad (1)$$

where $\omega = 2\pi$ times the frequency.

Let the voltage across the part *a* O of the inductance be some fraction of δ V, viz., *a* δ V, and that across the part O *b* some other fraction, viz., *b* δ V; the only limitations to *a* and *b* being

$$a + b \neq 1 \quad . \quad . \quad . \quad . \quad (2)$$

Let k_1 be the rate of increase of the current at the positive electrode with respect to the increase of the grid voltage, and k_2 the rate of increase with respect to the voltage at the positive electrode. The alternating component of the valve current through the part O *b* of the inductance is then

$$(k_1 a . \delta V - k_2 b . \delta V)$$

If δ W denotes the mean power supplied to the circuit, then

$$\delta W = b . \delta V (k_1 a . \delta V - k_2 b . \delta V) = (k_1 a b - k_2 b^2) . \delta V^2 \quad (3)$$

With the foregoing assumptions, the power expenditure in the circuit is $\delta I^2 R$, R being the effective resistance of the oscillatory circuit.

The conditions necessary for a small oscillation to build up to a large one are therefore

$$(k_1 a b - k_2 b^2) \delta V^2 > \delta I^2 R \quad . \quad . \quad (4)$$

But $\delta I = \frac{\delta V}{\omega L}$, and so the condition becomes

$$k_1 a b - k_2 b^2 > \frac{R}{L^2 \omega^2} \quad . \quad . \quad . \quad (5)$$

And putting $\omega^2 = \frac{1}{L C}$, which is nearly true, the condition reduces to

$$k_1 a b - k_2 b^2 > R C / L \quad . \quad . \quad . \quad (6)$$

or

$$L a b k_1 > R C + L b^2 k_2 \quad . \quad . \quad . \quad (6a)$$

With power valves the term $L b^2 k_2$ is sometimes much greater than the term R C, and when this is the case the approximate conditions for the maintenance of oscillations become $a/b > k_2/k_1$, which is simply an expression of the requirement that the oscillation line must lie as shown in Fig. 10 and not as in Fig. 12.

Equation (3) is also of interest in that it gives a value for the "negative resistance" of the valve. Putting $\delta V = L \omega \delta I$, the power supplied to the circuit is

$$\delta W = (k_1 a b - k_2 b^2) L^2 \omega^2 . \delta I^2$$

$$= \frac{L}{C} (k_1 a b - k_2 b^2) . \delta I^2$$

from which it follows that the negative resistance is

$$R - = \frac{L}{C} (k_1 a b - k_2 b^2) \quad . \quad . \quad (7)$$

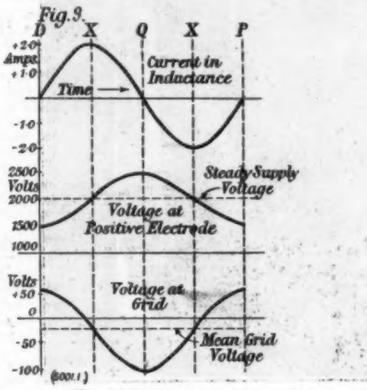
The required conditions for the maintenance of oscillations is that this negative resistance shall exceed the actual resistance, R, i.e., that

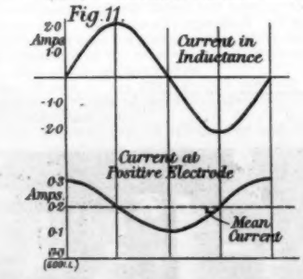
$$\frac{L}{C} (k_1 a b - k_2 b^2) > R . \quad . \quad . \quad (6a)$$

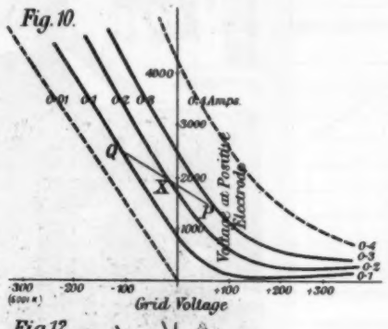
which is identical with equation (6).

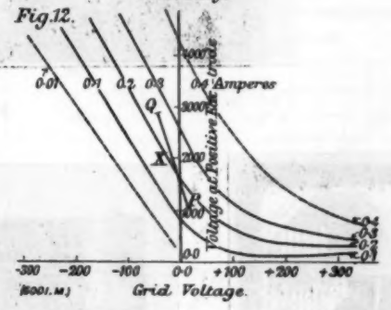
Assuming that the necessary conditions are complied with, any small oscillation that may be started by the closing of a switch or by any other means will gradually increase in amplitude. The corresponding oscillation line will lengthen proportionally, and in course of time will extend into regions where the values of k_1 and k_2 are no longer constant throughout the whole of the cycle, and the alternating component of the current from the valve will be no longer a sine wave. This effect will be particularly marked when the oscillatory current reaches such a value that the voltage at the positive electrode is reduced almost, or quite, to zero at the beginning of the cycle. In consequence of this irregularity the power supplied to the circuit from the valve will increase less rapidly than the square of the current in the main oscillatory circuit. Stable conditions where the power supply is equal to the power expenditure will thus be reached quickly, and no further increase of the current will take place unless the resistance of the circuit is reduced.

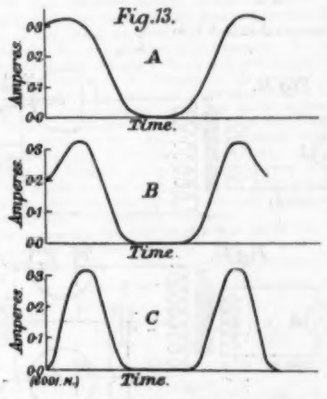
In Fig. 13 three cases have been taken. The circuit for which the curves are plotted consists of an inductance of 3,050 micro-henries and a capacity of 3,000 ohms, so giving a wave length of about 6,000 m. The connections to the valve are such that $b = 0{\cdot}26$, $a = 0{\cdot}04$, and the valve characteristics assumed are the same as those of Fig. 10. The curve A has been drawn for a current of 3·7 amperes, which will reduce the voltage of the positive electrode to 700 volts at the beginning of the cycle. The power supplied to the circuit is about 116 watts, and the current would be stable at this value if the resistance of the circuit was 11·8 ohms. In curve B a larger oscillatory current of 4·85 amperes is assumed, reducing the voltage at the positive electrode to 300 volts. A very marked kink is then appearing in the top of the wave of exciting current. The power supplied to the circuit is about 137 watts and the current would be stable at this value if the resistance of the circuit was 5·8 ohms. In curve C the oscillatory current has been taken as 5·7 amperes, which will just reduce the voltage at the positive electrode to zero. Compared with the curve B the irregularity of the wave will be much greater, and the power supplied to the circuit will be reduced both actually and relatively, with the result that this current could only be maintained if the resistance was











* Paper read before Section G of the British Association at Bournemouth, September, 1919.

reduced to about 3 ohms. These curves show quite clearly why it is that with a valve generator the current increases but little when the resistance of the circuit is reduced, unless some alteration is made to the adjustments. They also illustrate a self-protecting property of the valve. If the load is taken off there is a small increase in the current, accompanied by a reduction of the mean power taken from the supply. In curve A the mean current at the positive electrode is about 0·17 amperes, but in curve C it is only 0·12 amperes.

For the particular conditions in which the mid-point of the cycles of maximum amplitude is at the mid-point of the characteristics the R.M.S. value of the exciting current from the valve is $\frac{I_s}{2\sqrt{2}}$, I_s being the saturation electron current, and the R.M.S. value of the voltage across the part O b of the inductance is $\frac{V}{\sqrt{2}}$, V being the steady voltage applied to the positive electrode.

The maximum power that can be obtained from the tube is then

$$\frac{I_s}{2\sqrt{2}} \cdot \frac{V}{\sqrt{2}} = \frac{1}{4} I_s V$$

If I and V are the R.M.S. values of the alternating current and voltage in the oscillatory circuit, the stable maximum conditions are then approximately

$$I^2 R = \frac{1}{4} I_s V$$

But $I = \frac{V}{L\omega}$, and if the oscillation line just stops at the horizontal axis, $b V = \frac{V}{\sqrt{2}}$.

Fig. 14.

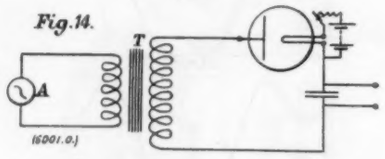
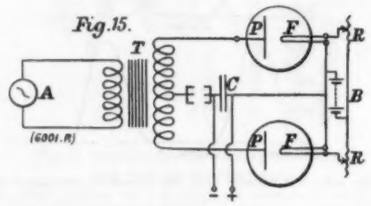


Fig. 15.



The average current taken from the supply is $\frac{1}{2} I_s$ at the steady voltage V_0. Hence the efficiency of the valve, neglecting the power supply to the filament, is 50 per cent.

to the grid so that the mid-point of the cycle is towards the bottom of the characteristics, efficiencies up to as high as 75 per cent. can be obtained. A battery may be used for this purpose, but the circuit shown in Fig. 8, page 492, is preferable. Here the small rectified current from the grid passes through the resistance R_3 and so automatically maintains the grid at a negative voltage depending upon the amplitude of the oscillations.

This theory of the action of the circuits is applicable to any form of circuit. If, for example, a mutual coupling

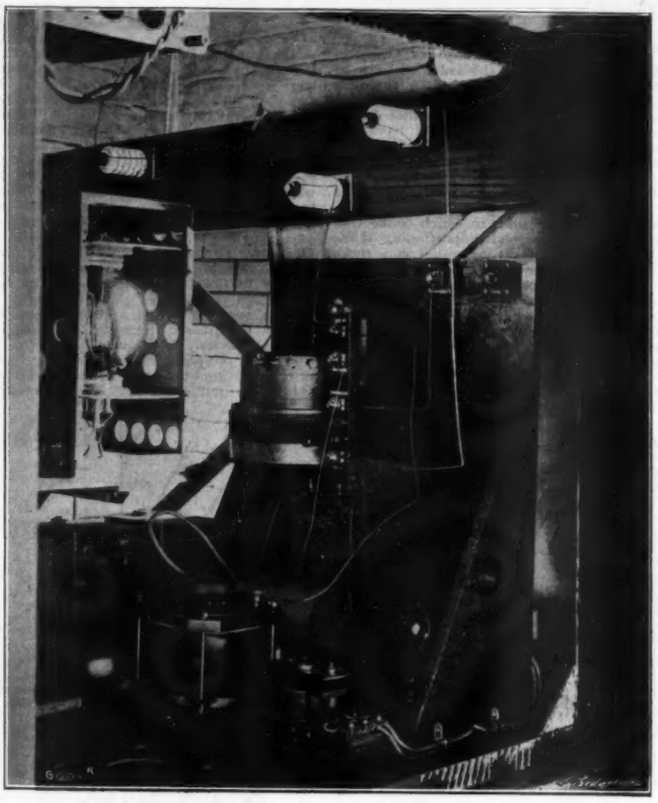


Fig. 17.

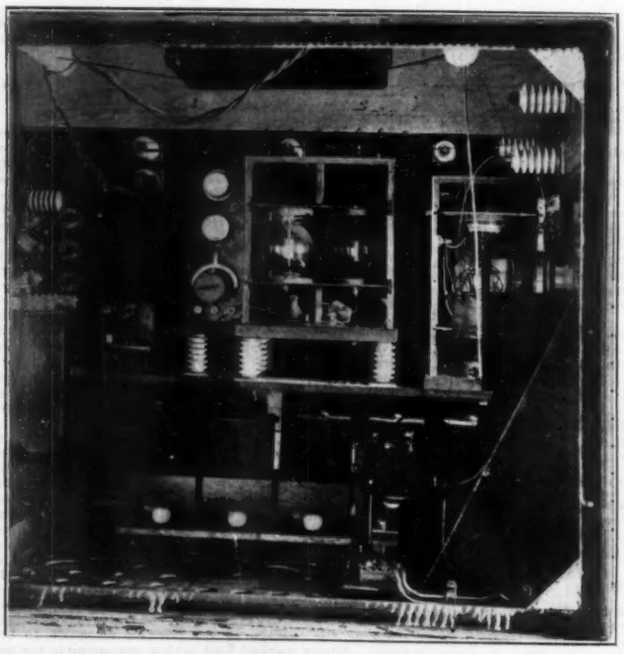


Fig. 16.

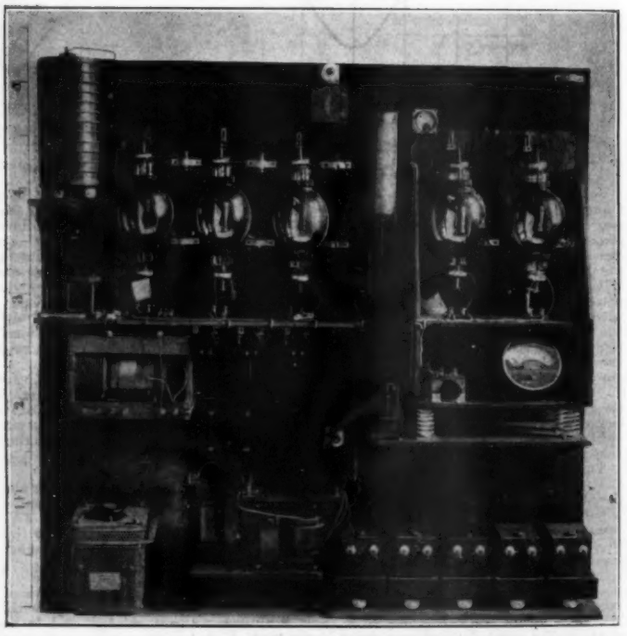


Fig. 18.

Hence $$b^2 = 2 \frac{V}{I_s} \frac{R C}{L} \quad . \quad . \quad . \quad (5)$$

This equation gives the suitable value for b, and the corresponding value of a for the maintenance of the oscillations follows from equation (6).

This, however, is by no means the highest possible efficiency. Any arrangement of the valve and circuit that leads to an irregular wave of current giving a considerable power to the circuit, but having at the same time a low arithmetic mean, will give a much higher efficiency than 50 per cent. If a steady negative voltage is applied

of the grid is used, the grid voltage can still be expressed as a fraction of the voltage across the main inductance. If M is the mutual inductance, $a = \frac{M}{L}$, and the condition for the building up of the oscillations is

$$M b k_1 > R C + L b^2 k_2 \quad . \quad . \quad (9)$$

(4) *A Short Description of Certain Valve Transmitting Sets Used for Wireless Telegraphy in the Naval Service.*—Most of the valve transmitting sets in the Naval Service have been designed to work as far as possible from the power supply of existing spark telegraphy sets. This power supply is in the form of a high-voltage single-phase alternating current, of frequency from about 100 cycles per second upwards. To use this supply it is therefore necessary to fit rectifiers which will convert the alternating supply into a direct-current supply. The rectifiers used are two electrode valves differing from the three-electrode valves only in that the grid electrode is omitted. Fig. 14 shows a simple method of connecting up a two-electrode valve for this purpose. During the half cycles when the positive electrode A is positive to the filament, electrons are drawn from the filament. During the other half cycles no reverse current can pass. Consequently, there is a deficit of electrons on the plates of the condenser connected to the filament of the valve. The terminals of the condenser C can then be used as a direct-current supply. By increasing sufficiently the capacity of the condenser the uniformity of the direct-current supply can be increased to any desired extent. The numerical relationship of rectifiers of this type have been given recently by the author.*

An improvement on the simple circuit of Fig. 14, involving the use of two valves, has generally been used. Fig. 15 shows such a typical circuit arrangement. With this system one valve is operative during each half cycle and for a given uniformity of the direct-current supply, the capacity required in the condenser C is much less. The facts that the mid-points of the secondary windings of the spark set transformers were already connected to earth, and that the whole secondary voltage was usually in excess of that required for the valves, were additional reasons for the adoption of the two-valve system.

For the oscillating circuit two systems have been used. One in which the aerial has constituted the capacity in the circuit and the other an arrangement of coupled circuits, in which the aerial circuit is separately tuned and is loosely coupled to an oscillating circuit connected to the valve.

When using the aerial as the capacity, the circuit arrangement is as shown in Fig. 8, with the addition of the necessary switches for the control of the oscillations in accordance with the Morse signals to be sent. This switch has to perform two functions, viz., to break the primary supply to the transformer and to throw the earth connection of the aerial coil over to the receiving instruments. Magnetically-operated switches have generally been used for this purpose, which are controlled by the operator in the receiving compartment by a single Morse key of the ordinary type.

Figs. 16 and 17 are photographs showing the general arrangement of one of the valve transmitting sets used in the Naval Service.

In the centre of Fig. 16 are the two rectifying valves, with the controlling rheostat and instruments on the left, the whole unit being mounted on porcelain insulators. The alternating supply from the spark set comes in on the extreme left, where parts of the spark set actually appear in the photograph. Below the rectifier unit are four condensers used for smoothing out the current from the rectifiers. The single oscillating valve is placed to the right of the rectifiers and appears on the extreme right of Fig. 16. Fig. 17 shows the additional apparatus required to couple the valve to the existing aerial circuit, together with a further view of the oscillating valve on the left. In the centre of Fig. 17 is the grid coupling coil. One part of this is connected in series between the aerial tuning inductance and earth. The upper part is connected to the grid, and in this set a variable condenser is used in parallel with this inductance in order to tune the grid circuit. The cylindrical object at the back of this condenser is the resistance R_3 of Fig. 8. The small magnetic switch in the front of Fig. 17 is the switch changing over the aerial connection from the earth connection to the receiving instruments in the interval between the Morse signals.

Fig. 18 shows the complete set of additional apparatus required for use with a much more powerful spark installation.

The complete rectifier unit is on the right, with the smoothing condensers below.

Three oscillating valves are used in parallel, the three filament regulators being situated immediately beneath them.

The grid coupling coil and grid circuit tuning condenser are in the centre on the left, and the R_3 resistance is in the left-hand top corner. At the bottom on the left is the alternator field regulator, and between it and the smoothing condensers are two transformers supplying the filament current for the valves.

In conclusion, the author would like to add a word of thanks to the staff of the Wireless Telegraph Department of H.M. Signal School, Portsmouth, for the assistance given in the preparation of this paper.

STEAMSHIP LINE FROM NEW YORK TO DANZIG.—We read in the *Marine Journal* that American financiers are reported to be contemplating the establishment of a steamship line between New York and Danzig, Poland.

* Paper read before the Physical Society of London, June 27, 1919.

ENGINE POWER AND HEIGHT.*

By H. T. TIZARD.

1. THE variation of engine power with height, *i.e.*, over big ranges of atmospheric pressure and temperature, is of considerable importance in the analysis of full-scale experiments on aircraft, and in the estimation of the "performance" of aircraft from a knowledge of the properties at ground level. It is now the practice to reduce all observed performances of aeroplanes to a standard atmosphere, which represents the average atmospheric conditions in the South of England. It is convenient for this purpose to refer atmospheric densities and pressure to arbitrary units, the unit of density being that of dry air at 760 mm. pressure and 16 deg. C. (= 0·001221 gm. per c.c.), and that of pressure being 760 mm. of mercury. The densities and pressures at different heights, referred to these units, are as follows:—

TABLE I.

Height in Feet.	Relative Density.	Relative Pressure.	Temperature Deg. C.
0	1·026	1·00	+ 9·0
5,000	0·874	0·829	+ 1·5
10,000	0·740	0·684	− 6·0
15,000	0·630	0·560	−16·0
20,000	0·533	0·456	−26·0
25,000	0·488	0·369	−35·0
30,000	0·374	0·296	−44·0

Fig. 1. VARIATION OF B.H.P. WITH TEMPERATURE.

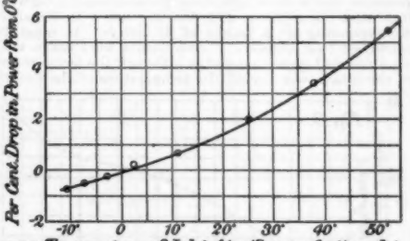
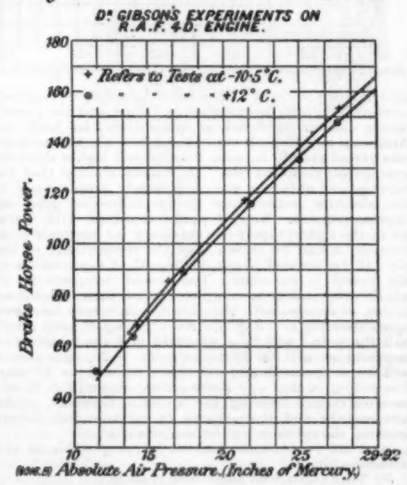


Fig. 2. VARIATION OF B.H.P. WITH PRESSURE.

Dr GIBSON'S EXPERIMENTS ON R.A.F. 4D. ENGINE.



2. The aerodynamic properties of aircraft at any speed depend only on the density of the atmosphere. When it was first decided to reduce all observed performances to a standard atmosphere the further assumption was made that the indicated and brake horse-power of an engine were also determined by the revolutions and density only, and were unaffected by change in temperature, provided the density remained constant. This assumption led to a method of reduction which did not involve a definite knowledge of the horse-power of the engine, and which may be briefly outlined as follows:—

The aneroid height indicator is a pressure instrument. If its zero be set at standard pressure of 760 mm., the true aneroid "heights" of 1,000 ft., 2,000 ft., &c., correspond to definite fractions, ·964, ·929, &c., of the standard pressure. The real difference in height corresponding to an indicated difference of height of 1,000 aneroid feet depends on the atmospheric temperature, and may be calculated by multiplying by a correction factor depending on the observed temperature. On a climbing test the following are the chief observations taken:—

(*a*) Time to each 1,000 ft. by aneroid.
(*b*) Atmospheric temperature at each 1,000 ft.

* Paper read before Section G of the British Association at Bournemouth.

(*c*) Airspeed.
(*d*) Engine revolutions per minute.

Reduction to the standard atmospheric conditions is then carried out by:—

(*a*) Calculating from the observations the apparent rate of climb in aneroid feet at every 1,000 ft. aneroid height.

(*b*) Multiplying these by the necessary temperature correction to obtain the true rate of climb.

(*c*) Calculating the corresponding standard heights from the corresponding observations of aneroid height (pressure) and atmospheric temperature.

(*d*) Plotting the true rate of climb against the standard heights and drawing a smooth curve (which is generally nearly a straight line) through the results.

The time to any height can be easily obtained from this rate of climb curve.

To obtain the maximum speed at different heights, the airspeed* ($\sigma^{\frac{1}{2}}$ V) flying level at full throttle at different aneroid heights is observed, and the atmospheric temperature at these heights. From the aneroid readings and the temperature can be calculated the atmospheric density and therefore the corresponding standard heights. The observed airspeed is corrected for errors of the instrument and the position of the pressure head, and then for density. This gives the true speed, which is then plotted against the standard height, and the figures for 5,000 ft., 10,000 ft., 15,000 ft., &c., interpolated from the curve.

3. This gives a simple method of reduction, which has been adopted by the French and U.S.A. governments, but which depends on the above assumption that at any standard height, which is defined for this purpose solely by density, the engine power will be the same at the same revolutions, and will be unaffected by changes in temperature and pressure. At the time the method was adopted there did not exist any very definite information on this point. It seemed a reasonable assumption to make on general grounds, and such records of performance that did exist supported it. One example was given in my paper to the Royal Aeronautical Society in 1917. This showed the figures obtained by the reduction of two tests of the same machine (a B.E.12 with 140 horse-power R.A.F. 4A engine) made on days on which the atmospheric temperature at corresponding standard heights above 5,000 ft. was considerably different.

The figures for the rate of climb at 10,000 ft., reduced in the above manner, were:—

Standard Height.	December 4, 1916.		December 6, 1916.	
	Rate of Climb.	Temperature.	Rate of Climb.	Temperature.
ft. 10,000 .. .. (σ = 0·74)	310	deg. C. −13·5	300	deg. C. −0·5

In this case a difference of 13 deg. C. at the same density had no effect on the rate of climb of the machine.

There has been a great deal of discussion recently on the accuracy of the density assumption, and the alternative view has been put forward that the power of an engine is unaffected by the temperature of the external air, provided the atmospheric pressure is constant, and that the assumption that the brake horse-power of an engine is proportional to the atmospheric pressure (not density) is very nearly true for all aircraft engines. If this were true a decrease in temperature at the same atmospheric density or standard height would cause a fall in available horse-power, since—

$$\text{Density is proportional to } \frac{\text{Pressure}}{\text{Abs. temperature.}}$$

It is proposed to consider which of the two hypotheses is most nearly supported by existing experimental data.

4. The question was really reopened as the result of experiments at the Royal Aircraft Establishment by Dr. A. H. Gibson on the direct measurement of the effect of changes in inlet air temperature on the brake horse-power of an engine on the ground. The experiments started with tests of a single-cylinder unit, and the results showed that an increase in temperature of 6 deg. C. diminished the brake horse-power by 1 per cent. On the density theory the horse-power should have decreased by rather over 2 per cent., while on the pressure theory there should have been no change, since the atmospheric pressure remained the same. Further experiments made with a 12-cylinder R.A.F. 3A engine showed that the effect in this case was smaller, a rise of 10 deg. C. being necessary to reduce the power by 1 per cent. The temperature was varied from 0 deg. to 55 deg. C. Subsequent experiments on an air-cooled R.A.F. 4D engine confirmed these results within temperature limits of −10 deg. and +55 deg. C.; in this case tests were also made under artificial altitude conditions by decreasing the pressure in the intake and exhaust pipes. The tests were all carried out at 1,400 engine revolutions per minute, the results of the variation of brake horse-power with temperature on the ground being shown in the following Table II, page 528, and in Fig. 1.

Two sets of tests were made under artificial altitude conditions. In the first set the intake air had a temperature of −10·5 deg. C., and in the second + 12 deg. The results for the brake horse-power show in any one

* NOTE.—In this paper the symbol σ is adopted for relative density, *i.e.*, density referred to that of air at 760 mm. pressure and 16 deg. C.; ρ represents true density.

set that it is approximately proportional to the pressure (and therefore also to the density, since the temperature is constant) at first, and then diminishes much faster than the pressure. The difference in the brake horse-power for the two sets at any one pressure is about 3 per cent. throughout, the difference in temperature being 22·5 deg. C., or about 8 per cent. in absolute temperature. It is, however, the change in indicated horse-power that is of most interest under these conditions. To calculate this, Dr. Gibson assumes that the mechanical losses on the ground are 12 per cent. of the indicated horse-power, and that of this 40 per cent. represents pumping losses, which vary as the density, and 60 per cent. represent frictional and other losses which are independent of the density. On this assumption he shows that, although down to a pressure corresponding to a height of 23,000 ft., the indicated horse-power and petrol consumption per hour are both approximately proportional to the pressure or density in any one set; at lower pressures still the indicated horse-power falls off more rapidly and the petrol per indicated horse-power increases. Dr. Gibson's estimate of the pumping losses seems high, but a variation would not much affect the calculated results at lower densities.

Table II.

Air Inlet. Temperature, Deg. C.	Brake Horse-Power.	Percentage Loss in Power referred to Brake Horse-Power at 0 deg. C. as Standard.
−10·5	154·4	−0·6
− 7·5	154·2	−0·5
− 3·0	153·9	−0·3
0·0	153·4	0·0
+ 2·0	153·0	0·2
+11·5	152·3	0·7
+25·5	150·3	2·0
+38·0	148·2	3·4
+53·0	145·1	5·4

His results at 12 deg. are given in the following table, and in Fig. 2 indicated horse-power at −10·5 deg. and 12 deg. C. is plotted against relative density.

Table III.—*Temperature of intake = 12 deg. C.*

R.P.M.	Relative Pressure.	I.H.P.	B.H.P.	$\frac{\text{I.H.P.}}{\text{Pressure}}$	$\frac{\text{B.H.P.}}{\text{Pressure}}$	Petrol Consumption per I.H.P. Hour.
						pints.
1,400	0·923	168·3	147·4	182	160	0·51
1,400	0·838	152·7	132·6	182	158	0·51
1,400	0·725	134·7	115·6	186	160	0·51
1,400	0·580	109·4	91·5	188	157	0·55
1,400	0·465	80·3	63·4	173	136	0·65
1,400	0·384	66·0	49·8	172	130	0·73

5. Experiments on the same lines, but carried out under conditions more similar to those obtaining in actua flight have been made at the Bureau of Standards in the United States. The engine under test was installed in a concrete chamber from which the air could be exhausted. The entering air passed over a series of refrigerating coils, by means of which the temperature could be lowered down to − 20 deg. C. The power was absorbed by a swinging field dynamometer. A large number of results were obtained with an 8-cylinder Hispano Suiza engine, the temperature, pressure and compression ratio all being varied. I will quote first the results of measurements of horse-power at 1,500 revolutions per minute when the pressure was varied. A Claudel carburettor was fitted and the petrol adjusted by hand in each case to give the maximum power. The tables below show results at 0 deg. C.:—

Table IV.—*Compression ratio, 4·7 to 1.*

Barometric Pressure. Cms. Hg.	Brake Horse-Power.	Indicated Horse-Power.	Relative Density.	Corresponding Standard Height.	B.H.P. / Pressure	I.H.P. / Rel. Density.
				ft.		
61·1	133·3	155·0	0·85	5,850	2·17	182
48·2	103·3	124·0	0·67	13,100	2·14	182
35·5	71·0	90·0	0·495	22,200	2·00	182
27·7	52·4	70·5	0·385	29,000	1·89	184

Table V.—*Compression ratio, 5·3 to 1.*

Barometric Pressure.	Brake Horse-Power.	Indicated Horse-Power.	Relative Density.	Standard Height.	B.H.P. / Pressure	I.H.P. / Rel. Density.
cm.				ft.		
62·1	140·4	162·5	0·865	5,400	2·26	188
49·8	110·8	131·0	0·695	12,000	2·23	188
37·6	80·4	100·0	0·525	20,500	2·13	190
25·6	50·6	69·0	0·355	31,200	1·98	194

It is clear that in neither set of experiments is the brake horse-power proportional to the pressure. On the other hand, the indicated horse-power is closely proportional to the density (and in this case to the pressure also, since the temperature is constant). To calculate the indicated horse-power the mechanical losses at ground level have been assumed to be in each case 23 horse-power (about 12 per cent. of the power at 5·3 compression ratio), and of these 8 horse-power is taken to represent throttling losses which are proportional to the density and 15 horse-power independent of the density. The observed increase in $\frac{\text{indicated horse-power}}{\text{density}}$ from 4·7 to 5·3 compression ratios agrees well with the values calculated on the expected increase in efficiency.

The effect of a variation in air temperature has also been investigated in the same laboratory between temperature limits of − 20 deg. C. and + 50 deg. C., and at different pressures. The mean of all the results is expressed in the form—

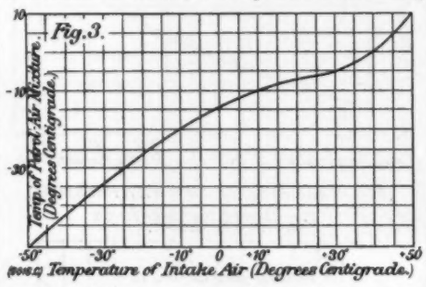
$$\text{Ratio of horse-powers at } t_1 \text{ deg. and } t_2 \text{ deg. and constant pressure} = \frac{529 + t_2}{529 + t_1}$$

The "pressure theory" assumes that a change in temperature has no effect if the pressure remains constante while the "density theory" assumes that the chang, would be proportional to—

$$\frac{273 + t_2}{273 + t_1}$$

so that the American results with the Hispano lead to a variation almost exactly half way between that assumed by the two theories.

6. The experiments made at the Bureau of Standards differ therefore from Dr. Gibson's results in showing a greater effect of a change of temperature at constant pressure, and in showing a closer proportionality between indicated horse-power and density, down to densities corresponding to a height of 30,000 ft. It must be remarked that Gibson's measurements were taken with an air-cooled engine, and that although the temperature of the intake was varied, the temperature of the cooling



air remained the same. The conditions did not therefore correspond closely with flight conditions, and the experiments cannot be taken as conclusive. In both the American and English experiments also the temperature was varied mainly between limits much higher than the average air temperatures. Dr. Gibson showed that the horse-power obtained was very nearly proportional to the absolute temperature in the induction pipe—an important point. Now, if petrol is mixed with warm air in the right proportions necessary for complete combustion, it can be shown that the temperature of the air will be lowered about 40 deg. C. if evaporation of the petrol is complete. The lowest temperature at which evaporation is complete under these conditions varies, of course, with the petrol, but it may be taken approximately as 0 deg. C. At − 10 deg. C. only about half the petrol will be evaporated and the lowering of temperature will be 20 deg. C. At − 20, one-quarter will be evaporated and the lowering will be 10 deg. Proceeding in this way a theoretical curve (Fig. 3) can be constructed showing the relation between intake temperature and temperature of mixture just before entering the cylinder, on the assumptions:—

(*a*) That evaporation goes as far as possible in the induction pipe.

(*b*) That there is no additional heating.

While these conditions do not hold in practice, the curve shows qualitatively what to expect. The smallest variation of mixture temperature with intake temperature occurs between intake temperature limits of about 0 deg. and + 40 deg., the difference being 14 deg. mixture temperature for 40 deg. change in intake temperature, which almost exactly corresponds to the variation in brake horse-power found by Dr. Gibson. Both below and above these limits the temperature variation in the induction pipe will be much higher. Gibson found the effect to increase at high temperatures, but his experiments were not carried far enough to show the expected increase at low temperatures. One would expect, therefore, the "density theory" to hold more exactly the lower the temperature or the greater the height. Obviously measurements of the temperature in the induction pipe during flight would be of great interest, but very few have been taken. Some experiments have been made in this direction by Captain Touissant, of the French Section Technique, but the results are not yet complete, although I understand that they bear out the above conclusions qualitatively.

7. Before proceeding to examine the evidence from observed performances of aeroplanes, and from measurements of propeller revolutions at different heights, i will be useful to consider a little more closely the theoretical aspect of the problem. There is general agreement that the indicated power is closely proportional to the mass of air entering the cylinder per revolution The principal factors which affect this ratio are, firstly, the specific heat of the working fluid, and, secondly, the heat loss to the walls during the working stroke.

No change in the true specific heat of the working fluid is to be expected within the range of pressures under consideration, but a decrease in the maximum explosion pressure would cause an increase in dissociation and, therefore, of apparent specific heat. It can be shown, however, that the effect of this would be small, and in any case might be partly compensated by a slight increase in the petrol/air ratio. As for the heat loss, although little is known definitely about its variation with pressure, it seems reasonable to suppose that the variation is small, *i.e.*, that the percentage loss is independent of pressure, particularly if the greater part of the loss is due to convection by the highly turbulent gases striking the cylinder walls. What loss in relative indicated horse-power might be expected from both of these causes would be neutralised to a certain extent by the increased volumetric efficiency resulting from lower throttling losses—this is apart from any variation in volumetric efficiency due to a change in temperature. Within the limits we are considering, therefore, the actual indicated horse-power may be taken as very closely proportional to the density of the charge, and this is supported by the above bench results obtained by varying the intake pressure, but keeping the temperature constant, and thereby avoiding complications due to varying temperatures in the induction pipe. It is also supported by the observation that down to a pressure about half the normal pressure the petrol consumption per indicated horse-power hour is sensibly constant.

There are a number of other small factors affecting maximum engine power in flight, but in so complicated a case it seems hardly worth while dwelling on theoretical considerations, the importance of which cannot be accurately estimated. It seems clear, however, that the principal point at issue is the effect of a change in the density of the external air on the density of the charge, and that this depends largely on the variation of the temperature of the charge with the external temperature under different conditions. Reasons have already been put forward to show that although the change in temperature in the induction pipe may be only one-third of the change in external air temperature when the latter is varied from 0 deg. to 40 deg. C., yet a lower temperature still the relative effect may be much greater. Reference may be made to one more point of some importance. It is often assumed that to ensure efficient distribution and combustion it is necessary to vaporise all, or nearly all, the petrol in the induction pipe, and that this condition is brought about by keeping the carburettor and induction pipe warm. This contention appears to be unsound. Efficient distribution does not necessitate complete evaporation, but can be obtained by efficient spraying and by preventing liquid petrol actually collecting on the walls of the induction pipe. Jacketing the induction pipe prevents petrol settling on the walls, but by no means ensures complete evaporation, and does not in practice increase very much the mean temperature of the petrol air mixture. Gibson showed the difference in temperature in the induction pipe of a R.A.F. 3A engine with and without exhaust muffs to the carburettor to be about 5 deg. C.

Further, it is obvious that the volumetric efficiency is higher if all the petrol enters the cylinders in a finely-divided liquid state than if it is all evaporated, so that from this point of view complete evaporation is not even desirable, although at ordinary temperatures a large amount of evaporation cannot be avoided. Finally, we have only to consider that even at a temperature of 0 deg. C. in the induction pipe petrol is largely evaporated during the time of its passage from the carburettor to the engine—which, assuming a velocity in the pipe of 120 ft. a second and an average length of pipe of 2 ft., takes about one-sixtieth of a second — and that at 1,800 revolutions per minute it spends nearly twice this time in the cylinder before the explosion, during which period it is first mixed with hot exhaust gases and then raised to a high temperature on compression, to realise that there is plenty of opportunity, even if the whole of the petrol entered the cylinder in a finely-divided liquid state, for its evaporation and mixture to be completed before explosion takes place. These remarks apply, of course, only to "aviation" petrol; if a fuel of high boiling-point were used the argument would not stand.

(To be continued.)

THE ACTION OF IRON OXIDES UPON THE ACID FURNACE STRUCTURE.*

By J. H. Whiteley and A. F. Hallimond, M.A.

(Stockton-on-Tees).

The durability of the structure of the acid open-hearth furnace is largely dependent on the corrosive action and accumulation of iron oxides carried from the furnace by the outgoing gases. In the hotter parts, such as the ports and blocks, these compounds are absorbed by the silica bricks and cause a lowering of the melting-point with consequent wastage; in the cooler parts, such as the regenerating chambers, the accumulation of the oxides eventually chokes the gas passages and necessitates a renewal of the chequer work. In the following pages the source of these products is first briefly considered, and a method is described by which the comparative amounts present in the gases at the various stages of the process were ascertained. A descriptive account is then

* Paper read before the Iron and Steel Institute, on Friday, September 19, 1919.

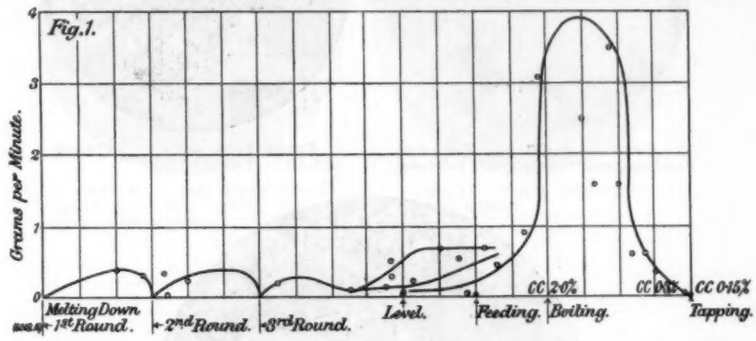
given of their action on different parts of the furnace structure, after which some possible methods of counteracting their deleterious effect on the structure are discussed. Finally, the microstructures of several of the solidified melts of silica and the iron oxides are described, as the microscopic examination of the various materials after service in the furnace is of considerable value in the study of their refractory properties.

Sources of the Materials which Accumulate in the Chambers.—In considering the possible sources of the accumulated materials, the low percentage of manganese oxide in the drip from the uptakes (analysis, Table I) makes it at once clear that no appreciable amount of ordinary furnace slag (which contains about 10 per cent. MnO) is carried over into the chambers; the slope of the ports is sufficient to make it impossible, under ordinary conditions, for the slag to run over into the slag pockets. In the same way the very low content of silica in the air-chequer dust (analysis, Table II) shows that, though this is mainly Fe_2O_3, it is not composed chiefly of ore particles, for the ores used contained about 8 per cent. of silica; the small difference between the silica content of the dust from the gas and from the air chequers also shows that no great proportion of the gas dust is derived from the flue dust in the producer gas, for this generally contains over 30 per cent. of silica. It is clear, therefore, that the main source of the oxide which accumulates in the regenerators must be the metal itself, and the material must be carried over by the gases either as suspended particles or as vapour.

In order to determine the relative amounts of matter suspended in the outgoing gases at different periods a short piece of weighed silica tubing was inserted horizontally in the waste gases near the top of the air uptake. The tube was loosely fitted into another longer tube that served as a holder; to prevent the junction of the two from being cemented by the action of the hot gases it was protected by a third outer tube that extended for a distance of about 1 in. beyond the holder. The testing tube was cleaned and weighed before each exposure and adjusted so as to project for a fixed distance (about 3 in.) beyond the guard tube. A period of exposure varying from 2 minutes to 5 seconds was given so as to produce a deposit weighing about 0·50 gramme in each test. From this the quantity of material that would be deposited per minute was calculated, and thus a comparative estimate of the matter in suspension at different stages was obtained. The results of a large number of tests taken during the working of several different charges have been plotted in the graph shown in Fig. 1. The ordinate represents the weight in grammes of oxides deposited per minute upon the test tube (3 in. long and 1 in. diameter) when inserted horizontally in the waste gases in the air uptake.

Although the estimate obtained by this method is only approximate in character, the results leave no doubt that the main quantity of oxide is carried away by the gases during the "boil" and not during the period between melting and boiling, as stated by Paul.* Even when the furnace was allowed to stand during the early period of the boil for a considerable time without further ore additions, no appreciable diminution in the quantity deposited was obtained, a fact which again shows that the suspended matter is not composed chiefly of ore particles. The particles are present in the gases as liquid drops, for it was frequently observed that they had formed long splashes on the sides of the tube. The under side of the tube always remained clear, but was stained red during the hotter periods by very fine material or else vapour. In the melting stages, the suspended particles are no doubt due to the spitting of the metal as it fuses, but the origin of the oxide when the molten metal is covered with slag is less certain; it may possibly be due to the presence of iron vapour in the numerous bubbles of carbon monoxide formed throughout the "boil,"† or more probably to the spurting of the metal from the bath. The absence of slag in the suspended material is a very noteworthy feature. It has been suggested that dust is carried back into the furnace on reversal;‡ tests made by inserting a clean tube in the ingoing current of air at the top of the uptake failed to show any sign of such action, for the tube remained perfectly clean after an exposure of several minutes.

Fig. 1.



The above experiments make it clear, then, that the fluxing material is mainly derived from the metal itself, both in the melting stage and during the subsequent boil. That part derived in melting will contain a proportion of MnO varying from 0·5 per cent. to 2 per cent., according to the analysis of the charge, whilst the particles given off during the boil will be practically free from this oxide. The low MnO content of the chequer dust (Table II., page 530) thus confirms the above experimental evidence, which shows that very large amounts are liberated during the boil. The action of this suspended iron oxide on the various parts of the furnace structure will now be considered.

The Corrosion of the Furnace Lining.—Much attention has lately been given to the structure of the roof-bricks before and after service, and several estimates of the maximum temperature attained at the surface have been made. In this connection it must be borne in mind that the temperature gradient from the surface inwards is very great; the cristobalite zone, which represents approximately that portion of the brick above 1,470 deg. C., is usually about 1 in. in thickness, and, since optical measurements show the flame temperature at the hottest periods to be about 1,700 deg. C., and the surface temperature of the roof to be about 1,600 deg. C., it follows that the gradient must be at least 100 deg. C. per inch. As the temperature rises during the working of a charge, the surface of the bricks becomes coated with a thin layer of viscous material, composed of silica and iron oxide, which flows slowly down the sides of the furnace and either mixes with the fettling at the top of the banks or enters the slag. The presence of this viscous layer probably protects the underlying portions of the bricks from the extreme temperatures.

Fig. 2. OUTER ZONE OF A ROOF-BRICK. (DIAGRAMMATIC).

The numerous small stalactites which can be seen hanging from projections in the roof and walls are the result of the formation of this fused layer. Several of these were collected from a furnace out for repairs and their silica and iron contents were ascertained. An average analysis is given below:—

	Per cent.
SiO_2	65·30
Fe_2O_3	31·70
Al_2O_3	1·20
MnO	0·70
CaO	0·90
MgO	0·05

The silica content is higher than that of the drip from any other part of the furnace; this corresponds with the high temperature of formation, since the drip consists of a melt in contact with excess silica and the solubility of silica increases with the temperature.

These small stalactites very frequently present a curious double structure, illustrated in Fig. 2, the upper portion consisting of material, mainly cristobalite, similar to that in the outer zone of the bricks, while the tip is composed of a dark cindery material which is much richer in iron oxide. Analysis of the two parts gave the following results:—

	Stem. Per cent.	Tip. Per cent.
Silica	75·0	38·0
Iron oxide	23·0	60·0

Although when the drip has slowly cooled in air the iron is found chiefly as magnetite, yet at the high temperatures attained in the furnace, a certain quantity of ferrous silicate will be present owing to the reaction of the magnetite with silica, the composition of the liquated portion approximating to that of the ternary eutectic between fayalite, silica, and magnetite.

In order to verify this conclusion, six parts of ferric oxide as chequer-dust (Table II) were intimately mixed with four parts of finely ground silica brick (SiO_2, 96 per cent.) and the mixture was heated for 15 minutes in a silica tube which was placed near the top of an air-uptake at the exit end of a furnace just before tapping. During the experiment the temperature of the outgoing gases would be at least 1,500 deg. C. A good melt was obtained which on analysis gave the following result:

	Per Cent.
Ferric oxide	26·9
Ferrous oxide	24·7
Silica	44·4

Calculation of the relative amounts of the three constituents present shows:—

	Per Cent.
Magnetite	39·0
Fayalite	18·0
Free silica	40·0

It was found that many silica brick particles were still present, and there can be little doubt that, given a longer heating, more fayalite would be formed. A polished section showed that the magnetite was imbedded in fayalite or fayalite glass and was very similar to that shown in Photo 9. Large grains of the unabsorbed silica brick were also to be seen.

Additional evidence of the reaction between the iron oxides and silica, even under the oxidising conditions prevailing in the air-uptake, was obtained from the action of the iron oxide in the waste gases on the silica tube itself. That part of the tube which had been exposed in the flue was coated with a layer of dark cinder, and several large drops had formed and flowed to the underside of the tube. Some of these were detached and analysed and were found to contain:

	Per Cent.
Magnetite	52·0
Fayalite	10·0
Silica	37·0

Under the microscope a large quantity of the ternary eutectic between magnetite, fayalite, and silica was seen to be present, in which was imbedded some grains of free silica. Further reference will be made to these reactions later.

The sharp division which separates the silica and cinder portions of the roof stalactite is probably connected with the peculiar form of the freezing point curve of silica,* the solidification of most of the free silica taking place quickly at a considerably higher temperature than that of the eutectic. The silica content of the drip is very high, and even at the highest temperature of the furnace the fused material that fills the interstices between the grains of cristobalite in the outer zone of the bricks will be in a very viscous condition. As the furnace cools this fused matter will very soon deposit most of its excess silica, and the mother liquor will become progressively richer in iron oxides. Thus, in spite of the falling temperature, the interstitial melt will become increasingly fluid through loss of silica, and so will flow readily between the grains.†

Now the presence of numerous blowholes throughout the body of the stalactite (but not at the tip) shows that dissolved gases have been set free as the silica separated. This would naturally expel some of the interstitial fluid which, as has just been described, collects in a drop at the tip of the stalactite. Similar gas-cavities are to be seen in the cristobalite zone of the roof-brick itself. Here, during freezing, the outer layer solidifies first and the interstitial fluid will, therefore, be forced upwards by the gas into the interior parts of the brick. This removal of impurities to the cooler parts of the brick is probably a beneficent action as has been remarked by Dr. Stead,‡ and in this respect the variation of the temperature of the roof during working probably serves a useful purpose, as each time the roof cools the expulsion of gases will force some of the accumulating impurities away from the danger zone. The presence of a third (or fourth) constituent such as lime will cause the freezing point of the eutectic to be lowered, so that it will be able to travel still further into the cooler parts of the brick. It has been proved by several workers that the highest concentration of lime in a used roof-brick occurs at the limit of penetration of the iron oxides, and the action of lime just mentioned would seem to afford a reasonable explanation of this effect. Another contributory cause for this curious removal of the impurities lies in the fact that each time the brick cools pure silica is precipitated in the outer zone, while the mother-liquor which contains the iron and other impurities is displaced and would probably concentrate within the brick, even if unassisted by the gases.

Corrosion of Ports and Uptakes.—In the ports and uptakes the velocity of the waste gases is increased by the constriction of the passages, and at the sharp turns the larger-sized particles of iron oxide are thrown against the walls, so that wherever the gases impinge a heavy fluxing action takes place. The fused material flows in a thin sheet down the walls of the uptakes and is received in the slag pocket or chamber below; round the openings of both gas and air uptakes it forms rings

* *Journal of the Iron and Steel Institute*, 1912, No. II, page 95.

† This explanation has been advanced by Cosmo Johns. *Journal of the West of Scotland Iron and Steel Institute*, vol. xxvi, part 3, page 36.

‡ Cronshaw, *Journal of the Iron and Steel Institute*: "Carnegie Memoirs," 1916, vol. vii, page 172.

* "The Acid Hearth and Slag," *Journal of the Iron and Steel Institute*, 1919, No. I, Fig. 1.

† Occasionally stalactites may be observed without the cindery tips but having blunt or even hollowed ends. In such cases it is practically certain that the tip when formed was sufficiently fluid to separate from the stem and fall on to the hearth.

‡ "Note on a Silica Brick from the Roof of an Open-hearth Furnace," Ceramic Society, May, 1919.

of large stalactites. Samples of these stalactites were obtained from three different furnaces and tested for silica and iron oxides; the analyses are given in Table I. The highest temperature attained in the uptakes is probably about 1,600 deg. C., but the low silica content of the air chequer-drips, as compared with the roof-drip, would seem to indicate that the average temperature of the fused layer is below that of the corresponding layer in the furnace.

The fact that the cristobalite zone beneath the surface layer of the bricks in the ports and uptakes is considerably less than one-half the thickness of that in the roof-bricks also points to the same conclusion.

Table I.

	Gas.	Air.	Gas.	Air.	Gas.	Air.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
SiO_2	64·6	19·6	48·6	33·0	60·2	19·6
FeO	26·8	28·9	35·0	17·0	18·9	12·6
Fe_2O_3	7·6	50·7	10·3	47·1	16·8	64·9
MnO	0·15	0·20	0·20	0·29	0·12	0·26

It will be seen that in the gas-drips the greater part of the iron exists as ferrous oxide, while in the air-drips ferric oxide predominates. This variation in the composition of the drips must be the result of the different conditions that obtain in the two cases. In the air-uptakes the gases are always oxidising in character, whereas in the gas-uptakes waste gases and producer-gas alternate, and there can be no doubt that the greater proportion of ferrous oxide found in the gas-drips is due to the reducing action of the latter gas. Unlike ferric oxide, ferrous oxide readily fluxes with silica, and the silica content of the gas-drip is consequently much higher than that of the air-drip. The effect of the formation of ferrous oxide through the action of the producer-gas is seen in the more rapid corrosion of the brickwork of the gas-uptakes.

The foregoing descriptions clearly show that the deleterious action of the furnace gases on the structures is largely due to the presence in them of iron oxide particles. If these particles were not continually projected upon the surface of the bricks in the furnace, ports, and uptakes, the wear would be greatly reduced, for the viscosity of fused silica itself is so high that the thin fused layer would flow extremely slowly. The corrosion of the furnace lining may be taken as proportional, therefore, to the amount of iron which is precipitated upon it. The presence in the bricks of substances such as lime and alkalies which "thin" the fused layer will be very harmful, while it may be presumed that if, by any means, the viscosity could be increased, the bricks would be better protected. The presence of a substance in the brick which would precipitate ferrous oxide at the temperature of the furnace might probably be of great value, for it would enable the iron content of the surface layer to be increased without diminution of the viscosity. There are certain compounds of ferrous iron, belonging to the spinel group, which remain solid at high temperatures, one of the best known being chromite. It is possible that if a brick could be made containing say 5 per cent. to 10 per cent. of chromic oxide, part of the iron oxide projected upon the brick in the furnace would form solid chromite, and the surface layer could thereby carry a considerably greater amount of iron than could be borne by the pure silica brick before its viscosity was lowered to the same extent. The use of chromic oxide is at present commercially impossible, but chromite itself is easily obtainable, and it might be of interest to examine the behaviour under various conditions of silica bricks containing this substance.

The Chequer-Work.—In furnaces of the older type the drip from the uptake falls directly upon a small slag pocket which is placed in the chequer-work and which soon becomes filled with the fused material; in furnaces of more recent design the drip falls into separate slag chambers from which the gases pass over a low wall into the chequer chamber, carrying with them only the lighter suspended particles. Even in the latter case the quantity of iron oxide carried by the gases is sufficient to cause the obstruction of the chequers after the lapse of some months. Beneath the blocks on which the chequer-bricks rest is a channel through which the gases pass to the chimney, and after the furnace has been in use for some time it is found that fluxed material has run down into this channel, where it hangs as stalactites and collects upon the floor. A certain amount of iron oxide dust is also found in the flues leading to the chimney, but the main portion of the iron oxide is undoubtedly retained in the chequer-work.

As already seen in the case of the drip from the uptakes, the state of oxidation of the accumulated material depends upon whether it is deposited in the air or the gas regenerators. In the former, the material is exposed either to the oxidising action of the hot air or the waste gases; in the latter, the waste gases alternate with producer gas and the average result is a strong reducing action which leads to the conversion of the greater part of the iron oxide to the ferrous state. On account of the great difference in the reactions which occur in the two regenerators, the conditions obtaining in the air and gas chambers will be described separately.

The Air-Chequers.—The obstruction of the chequer work through the deposition of the fine iron oxide dust is most noticeable in the air-chambers. This, however, is not due to any difference in the percentage of material carried by the gases; in fact, when making the comparative tests plotted in Fig. 1, it was repeatedly observed that the gases passing down the gas-uptake were more highly charged with the dust than those in the air-uptake, owing, no doubt, to the central position of the gas-ports. The greater obstruction is due to the retention of the bulky form in which the material is deposited owing to the constant oxidising conditions which prevail.

The uppermost layers of bricks are usually somewhat fluxed and cut away by the corrosive action of the hot gases, but in the body of the chequer-work, where the temperature is lower, the bricks remain intact. When fractured they show a brown coloration, most probably caused by the penetration of a little iron oxide vapour; the absorption of any appreciable amount of iron oxide is seldom to be seen even in the older type of furnace, unless for one reason or another the temperature of the chamber has been unusually high. The material deposited by the gases under normal working conditions is retained almost entirely in the spaces of the chequer-work, the top and sides and to some extent the under surface of the bricks being coated with a loosely coherent powder, the chequer-dust. Under the microscope the dust is seen to consist of minute spheres sometimes lightly fritted together and varying in diameter from about $\frac{1}{250}$ in. downwards (photo. 10); the mass is sufficiently coherent to withstand the force of the gases, and so the spaces are gradually filled with this material. A typical analysis of this dust is given below, and shows that it consists almost entirely of ferric oxide. The sample was, of course, taken from the cold chambers, and any ferrous oxide existing in the dust under working conditions will have been oxidised during the cooling; there can be no doubt, however, that even at the higher temperature attained the ferric oxide content greatly predominated.

Table II.—*Analyses of Chequer-Dust.*

—	Fe_2O_3.	Al_2O_3.	MnO.	CaO.	SiO_2.
	per cent.	per cent.	per cent.	per cent.	per cent.
Air chamber ..	95·90	0·40	0·40	0·05	3·0
Gas chamber ..	94·10	0·45	0·35	0·40	4·1

As already remarked, in cases where the temperature has been unusually high many of the bricks may be permeated by iron oxide. The iron content of a saturated brick is shown in Table III., and is mainly ferric, but this is probably due to subsequent oxidation when the furnace was again working cooler. That no considerable amount of oxidation occurred after going out is clear, for a saturated brick taken from a comparable position in the gas chamber contained but little ferric oxide.

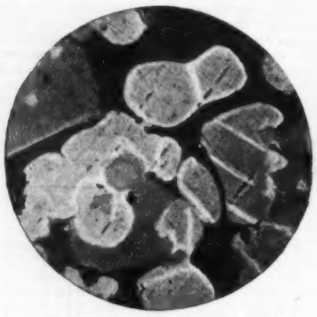


Photo 1. × 485. Best Tap. FeO and magnetite bright, fayalite half-tone.

Photo 2. × 485. Do. Etched with HCl. FeO, dark.

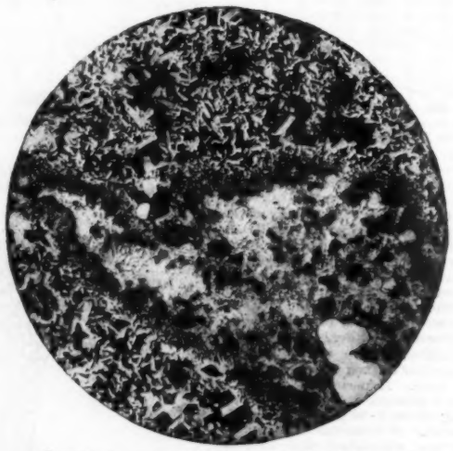


Photo 3. × 85. Used gas-chequer brick. Partly altered gannister in a groundmass containing fayalite.

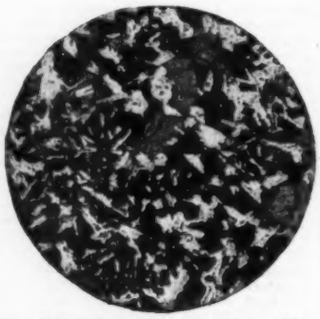


Photo 4. × 85. Air-chequer drip. Magnetite, fayalite and tridymite.

Photo 5. × 85. Gas-chequer drip. Binary entectic of fayalite and silica.

Table III.—*Analyses of Soaked Bricks.*

—	FeO.	Fe_2O_3.	SiO_2.
	per cent.	per cent.	per cent.
Air	0·30	26·1	71·80
Gas	22·90	3·7	71·60

The experiments given on page 529 strongly support the view that the material penetrating the brick results from a reaction between the overheated dust and the underlying silica.

In the air-chequers, a certain amount of fused material

drips from the upper courses of the chequer-work into the channel below the blocks. Analyses of three samples from different furnaces are given in Table IV., and the microstructure of the second is illustrated in photo. 4.

Table IV.

—	FeO.	Fe_2O_3.	SiO_2.
	per cent.	per cent.	per cent.
1	38·10	28·0	32·4
2	23·20	45·1	30·2
3	5·7	58·3	34·0

The FeO in (1) is unusually high, owing to a leakage of gas into the chambers towards the end of the run.

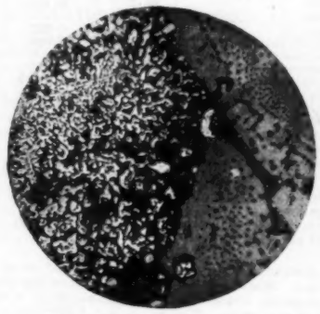


Photo 6. × 435. Binary entectic, fayalite-silica, and ternary entectic fayalite-silica-magnetite.

Photo 7. × 435. Binary entectic, fayalite-magnetite.

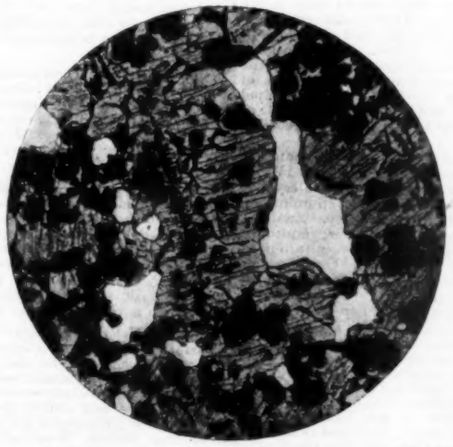


Photo 8. × 35. Mill cinder; crystals of magnetite in fayalite.

Photo 9. × 435. Binary entectic, magnetite-silica, in fayalite groundmass.

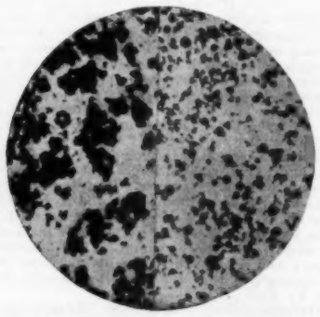


Photo 10. × 35. Dust from air-chequers (right) and gas-chequers (left).

The Gas-Chequers.—A very considerable accumulation of material takes place also in the gas-chequers, in fact it is very probable that the total proportion of dust caught here is as great as that retained in the larger air-chequers, but the effect on the draught is usually far less serious. The bricks are somewhat fluxed at the hottest zone; below, they retain their shape well. The absence of accumulated dust is a very noticeable feature, the passages remaining fairly clear except when they have become more or less completely choked by fused matter falling from the uptakes, as occurs in the older type of furnace. Only in the colder parts near the walls is any quantity of dust to be observed, and this is much fritted together, as can be seen in photo. 10. The silica content of the dust is usually slightly higher than that of the air-chequer (*cf.* analysis, Table II) dust, but otherwise the analyses of the two are identical; the absence of ferrous oxide in the gas-chequer dust is no doubt due to oxidation by air during cooling.

The bricks when fractured are found in almost every instance to be completely penetrated by a dark slag, and the analysis (Table IV., No. 2) shows that they have been saturated with ferrous oxide. The weight of a new brick is about 9 lb., but after fourteen weeks' service the saturated brick weighed on an average 11 lb., an increase of no less than 2 lb. per brick. This figure agrees well with the increase shown by the analysis. Since the gas-chequers in this instance contained about 6,000 bricks, the total weight of iron oxide absorbed during the period of working was over 5 tons. The material in the slag pockets and in the chequer spaced would probably amount to at least 8 tons, containing about 4 tons of iron oxide, so that it may be assumed that, at a very rough estimate, about 9 tons of iron oxide was retained in the gas-chambers alone. The amount which collects in the air-chequers is not so readily estimated, but it will scarcely be less than the above, so that, during the fourteen weeks' service, about 18 tons of iron oxide were carried by the gases from the furnaces. In this period 120 heats of 70 tons were made, so that, on an average, 3 cwt. of iron oxide per heat was deposited in the chambers by the gases.

In the gas-chamber, as in the air-chequers, fuse material runs down into the channel below, where it accumulates upon the floor, and, in the middle of the chamber beneath the uptake, often reaches the blocks, but thins out to perhaps 6 in. in depth at the margins. Sometimes, in the older type of furnace, the quantity formed is so large that it partially fills the chequer spaces and united the brick-work into a solid rock-like mass. Much of this material is derived from the uptake drip, which first fills the slag pocket and then overflows and runs through the spaces in the chequer beneath; a certain amount is, no doubt, also derived from the residue of oxide not absorbed by the bricks. The composition of the drip below the chequers in two furnaces is given in Table V.; in each case it approximates to the eutectic between fayalite and silica. The structure is seen in photo. 5.

Table V.

—	FeO.	Fe_2O_3.	SiO_2.
	per cent.	per cent.	per cent.
1	51·6	10·4	35·6
2	55·5	6·3	35·6

Concluding Remarks.—There can be no doubt that the requirements for the refractory materials to be used in the structure of the open-hearth differ considerably according to the part of the structure under consideration, and if further progress is to be made it will be necessary, in an increasing degree, to utilise the various materials obtainable in those parts of the furnace where they can be employed to the best advantage. It has been justly remarked by Cronshaw that an excellent brick may be condemned if it happens to be used in the wrong place. In the acid process the destructive agent is almost pure iron oxide, which is a basic substance, and the use of acid materials in the ports and blocks where the heaviest wear takes place seems theoretically unsound. On reference to Fig. 1 it will be seen that the greatest quantities of iron oxide are present in the waste gases, during the early stages of the "boil," at the time when the furnace is working at a high temperature, and much care and skill is required of the smelter in the regulation of the heat of the furnace in order to prevent an excessive erosion of the posts and block faces at this stage. The need for a cheap and suitable basic brick which will withstand the action of the iron oxide is evident, and the production of such a brick for use in the above parts of the furnace would probably effect a considerable economy.

In furnaces of the older design the period of service is often determined by the failure of the regenerators, but in the newer type, where separate slag chambers are provided, trouble is generally first experienced with the upper structure. When this part is being rebuilt, however, the occasion is usually taken to clear the chequers, if it is considered that they will not last another run. In both types, therefore, an improvement in the life of the chequers would be of value, for even in the latter case it would be of advantage if the period of service could be extended.

From the foregoing description it will be seen that the great difference in the conditions of the air and gas chambers after use is due in a very large degree to the character of the gases passing through them. The melting points of mixtures of silica and either ferric oxide or magnetite found in the air-chequers are much higher than those of mixtures of silica and ferrous oxide formed by the reducing action of the gases in the gas-chequers. The only mixtures fluid at the average temperatures of the chequer-work are those near the eutectics of the system FeO–Fe_2O_3–SiO_2. If conditions become sufficiently oxidising the melt is transformed into a mixture of solid iron oxide and silica (tridymite). At a higher temperature under the same atmosphere this mixture may fuse again with the evolution of oxygen and the formation of some ferrous silicate. In the oxidising atmosphere of the air-chequers the temperature is usually not sufficiently high to cause fusion and the dust accumulates in the solid state in contact with the silica bricks; in the gas-chequers the alternate passage of a reducing gas causes the formation of a large quantity of ferrous silicate which yields a very liquid melt and is readily absorbed by the porous silica bricks. It is clear, therefore, that a high degree of porosity is required in bricks which are to be used in the gas-chequers. In an air-chequer brick, on the other hand, a high porosity does not seem essential, and a compact heavy brick having a high heat capacity and good conductivity will be preferable. Since the conditions in the air-chambers are always oxidising and the temperature is not generally high enough to melt the deposite iron oxides, there does not seem to be any reason why the compact iron-saturated bricks from the gas-chequers should not be used again in the less exposed parts of the air-chequers.

The prolongation of the life of the acid furnace can only be effected by removing, or counteracting the action of, the iron oxide which is constantly attacking the structure. It must be admitted that in the absence of any satisfactory method for cleaning very hot gases this problem presents many difficulties, and the few suggestions contained in the following remarks are given simply as an indication of the methods by which these difficulties may be attacked, for the authors recognise that each is open to serious objection. A short discussion of various possible ways of dealing with the problem may not, however, be without some value. The various methods proposed for counteracting the action of the iron oxide in the waste gases may be classed as follows:—

1. *Prevention of the Formation of the Oxide.*—So far as the oxide is derived from the spitting of the metal during the melting stage, the quantity formed may depend upon the kind of material used. It has already been shown, however, that the main evolution of oxide occurs during the boil and seems to be an unavoidable effect in the working of the process; there is little hope, therefore, of suppressing the oxide at its source.

2. *Arrest of the Particles before they Enter the Chequer-Work.*—The use of separate slag chambers has resulted in a great improvement in dealing with the coarser particles, which can be stopped in the passages leading to the chequer-work; but this, of course, does not prevent their action on the furnace walls and uptakes. The filter chequers proposed by Cronshaw* may also assist in the stoppage of the coarser particles, but there must always remain a large quantity of material which is so fine that it can only be arrested in the numerous small passages of the chequer-work itself.

3. *Absorption of the Oxide in the Chequer-Work.*—In the gas chequer-work, 2 lb. of oxide are absorbed per brick, a quantity which is a considerable fraction of the total amount entering the chamber. The porosity of the brick when new is thus an important factor. In the air-chequers usually very little absorption takes place. Since the dust which is here deposited is very bulky, the choking of the passages will be less the larger the interspaces between the bricks. Some advantage might, therefore, be gained by hollowing the surfaces of the bricks so as to increase the space in which the oxide can settle. The size of the interspaces permissible is limited, however, by the necessity for efficient regeneration.

By fusing or even fritting the dust the volume it occupies can be much diminished. If, therefore, the temperature of the chambers could be raised to a point high enough to cause fritting, say once a week, the air passages should not choke so quickly. Whether this can be done without damage to other parts of the furnace, or serious delay in the working, is a question which can only be decided by trial. It may be remarked here that if means could be devised for occasionally using the air-chambers for gas-regeneration, the accumulated oxide would be reduced and absorbed in the bricks as in the gas-chambers; the difficulties of such an operation seem, however, to be insurmountable.

4. *Removal of the Accumulated Material during Working.*—Proposals have been made for the removal of the oxide by the addition of a suitable flux which will cause the melt to flow freely through the chequer into an enlarged space below. The flux, if such can be found, would require to be injected as a fine powder into the streams of waste gases entering the chambers; in this way it would be distributed in exactly the same manner as the dust itself and would penetrate to all parts of the chequer-work. It seems possible that a careful consideration of the melting points of mixtures of various fluxes with iron oxide and silica might lead to the development of a method of this sort which could be of service, but it is obvious that a flux used for this purpose must not attack the bricks, and the possibilities in this direction are limited by the fact that melted oxides are apparently always mutually soluble to a considerable extent.

Note on the Microstructure of Melts Containing Silica and the Oxides of Iron.

An increasing amount of attention is now being given to the microstructure of slag inclusions and of the refractory materials. By an examination of the micro-section it is often possible to avoid tedious analytical work, and also to obtain information of much value in studying the behaviour of refractory materials in practice. For the purposes of ferrous metallurgy it would be difficult to lay too much stress on the necessity for a complete investigation of the melts containing the oxides of iron. Such a work is far outside the scope of the present paper, but it may be of use to give a short account of the melts of iron oxides and silica as observed in the acid furnace materials.

The behaviour of these melts is complicated by their reaction with the surrounding gases. In the fused material oxidation or reduction of the iron takes place, and the resulting composition is determined by the composition of the mixture, the temperature, the pressure, and the oxidising character of the gases. Some preliminary experiments made by the authors† indicate the general character of the reaction, and it is clear that to obtain melts covering the whole field of a triangular diagram such as that on which the first experiments were represented it will be necessary to use gases of widely different oxidising power; indeed it may be doubted whether even in pure oxygen under atmospheric pressure all the binary mixture of Fe_2O_3 and SiO_2 could be fused without partial decomposition of Fe_2O_3, while, on the other hand, attempts to produce pure fused FeO may yield metallic iron.

The separation of the crystalline constituents on cooling could be represented in the usual way by means of a solid diagram in which the temperature is plotted vertically from a triangular base which indicates the composition. The same diagram would serve for the expression of the behaviour of the melts in relation to the gas, the ranges of composition possible under the various fixed conditions being shown by a series of horizontal curved lines in the space representing the melted phase. Where the lines meet the stability surfaces a solid can coexist with the melt and gas, and it should be observed that crystallisation of the solid can be brought about not only by cooling, but also by a change in the composition of the gas. It is not necessary to discuss in detail the use of such a diagram, but it is important to note that when a solid is present the degree of oxidation will depend on the composition of the residual liquid, and that the system of lines which could be obtained by plotting the analyses of partially fused mixtures will differ from that for the complete melts.

From the examination of microsections of the slags and furnace structures a rough idea can be obtained of the general character of the ternary system FeO Fe_2O_3–SiO_2. The compounds met with, beside these oxides, were fayalite ($2FeO, SiO_2$) and magnetite (FeO, Fe_2O_3). Well-defined binary and ternary eutectics were observed between these compounds and silica, of which further details will be given in the description of the microsections.

* *Loc. cit.*

† *Loc. cit.*

Microsections.

Photo. 1.—"Best Tap" (FeO, 63·1 per cent.; Fe_2O_3, 26·5 per cent.; SiO_2, 7·8 per cent). Polished section. The rounded grains are FeO and are sometimes bordered by magnetite, of which a few separate crystals are present; the darker interstitial constituent is fayalite.

Photo. 2.—The same, etched with weak HCl. The FeO has dissolved and appears dark while the magnetite borders remain bright, and a shaft of magnetite can be seen deposited along a crystal-plane of the FeO in a manner which strongly recalls the structure of the free cementite in steels. The analyses indicate that the crystals of FeO can dissolve a considerable amount of Fe_2O_3 as was suggested by McCance; the magnetite seen in the FeO has probably been deposited from this solid solution during cooling. Crystals of FeO obtained in artificial melts often have a rhombic outline, but lack the rectangular symmetry of magnetite. As the SiO_2 increases, the proportion of fayalite increases very rapidly.

Photo. 3.—Transparent section of a used brick from the gas-chamber, showing the penetration of fayalite and the growth of tridymite in the ground-mass. In the centre is an angular fragment of ganister which still contains unaltered quartz, though the brick has been heated well above the transition point for about fourteen weeks.

Photo. 4.—Transparent section of drip from below the air-chequers (*cf.* analysis, Table IV.). A granular aggregate of magnetite, fayalite, and tridymite. This granular arrangement of the constituents is of frequent occurrence in the silicate melts; it takes the place of usual sequence of constituents and eutectics so often met with in metallic alloys. As will be seen below, the latter structure is also obtainable, and indeed the two types can sometimes be seen side by side in the same slide. The granular structure yields relatively little information about the diagram and the order of crystallisation may even be inverted. The conditions probably correspond with those obtaining during the crystallisation of rocks in which a similar absence of eutectic structure is often observed. The principal determining factors would seem to be the speed of crystallisation and the extent to which supercooling occurs.

In the layer which coats the uptakes of the air chambers and sometimes in the chequer drip (*cf.* Table IV., 3) the microsections show free ferric oxide. The crystals have elongated sections and under vertical illumination appear reddish in contrast with the magnetite. Analyses show that crystalline magnetite can hold in solution a considerable amount of Fe_2O_3 before precipitation of free hæmatite occurs. It is not certain that the materials analysed had been completely fused; oxygen was probably taken up during cooling.

Photo. 5.—Transparent section of drip from below the gas-chequers (*cf.* analysis, Table V.). Long crystals of the fayalite-silica eutectic with a few crystals of magnetite. The eutectic contains about six parts of fayalite to one of silica and has the crystal form of the predominant constituent, fayalite, but the crystals are rendered cloudy by the minute grains of silica present.

Photo. 6.—Polished section of mill cinder (about 35 per cent. SiO_2). The half-tone constituent is fayalite and contains grains of silica (dark), forming the binary eutectic. In this slag the proportion of Fe_2O_3 was sufficiently high to yield a noticeable amount of the ternary eutectic, which crystallises between the binary crystals. A patch of this is seen in the photo, the light constituent being magnetite. The fayalite is not present in large amount; as is common in these cases, there is a strong tendency for the growth of the binary eutectic to continue at the expense of the ternary, the third constituent (in this case magnetite) being left in excess in the residual liquid. The ternary point would appear to lie in the neighbourhood of the composition Fe_2O_3 20 per cent., SiO_2 40 per cent.

Photo. 7.—Polished section of mill cinder (FeO, 55 per cent.; Fe_2O_3, 22 per cent.; SiO_2, 20 per cent.). Binary eutectic of fayalite with magnetite. The faint lines below the oval patches of magnetite are due to rods of this substance which lie at a low angle beneath the surface of the transparent silicate; they are marked transversely with interference bands. This eutectic is not common; the magnetite is usually scattered in small grains throughout the large fayalite crystals, as seen in Photo. 8.

Photo. 8.—The same, transparent section. The structure is for the most part granular, but the bacillary eutectic of photo. 7 can be seen in places. The fayalite crystals have been separated by the gas expelled on freezing. Photos. 1, 6, 7 and 8 represent the range of structures commonly found in the mill cinders.

Photo. 9.—Polished section of a melt prepared in the oxygen furnace. Binary eutectic of magnetite and silica in a ground-mass consisting mainly of fayalite. This eutectic is common in the drip from the air-chambers; the silica is present in smaller proportion than the magnetite, and the crystals have the form of the latter constituent. The mode of formation of the rounded silica grains is well seen. A structure rather like this, but without crystal outlines, is sometimes produced by the oxidation of solid fayalite at high temperatures.

Photo. 10.—Dust from the chequers. That on the left is from the gas-chamber, on the right from the air-chamber.

Solubility of Ferric Oxide in Solid Fayalite.

The fayalite of the mill cinders has uniformly a pale brown colour which is deeper than that of the same mineral in the acid slags. In the former case the mineral is formed in the presence of a considerable amount of ferric oxide, but the staining does not proceed beyond a pale brown tint in thin section. In order to ascertain the nature of the stain, a well-crystallised cinder was crushed and the fayalite isolated by a series of magnetic separations. The pure silicate thus obtained had the following analysis:—

Table I.

—	1.	2 (equivalent)	3 (theoretical)
	per cent.	per cent.	per cent.
SiO_2	29·3	0·488	29·4
FeO	66·6	0·925	70·6
Fe_2O_3	0·85	—	—
MnO	1·55	0·022	—
CaO	1·40	0·025	—

$\frac{1}{2}$ RO : SiO_2 = 0·486 : 0·488

It is clear that the crystals contain a small amount of dissolved Fe_2O_3; this may possibly be present as magnetite, in fact this is much more probable, but the determination of the excess FeO is exposed to a greater risk of error since it is dependent on the exact estimation of the silica and total FeO, and the matter cannot be decided without extremely careful preparation and analysis.

CATALOGUES.

Italian Railways.—The representatives of the Italian State Railways send a handsomely-printed little pamphlet drawing attention to their offices at 12, Waterloo-place, Regent-street, S.W., where intending travellers are freely supplied with all information.

Fire Prevention.—The September issue of *Fire*, published monthly at 36, Whitefriars-street, E.C. 4 (6*d.*), contains many notes or short articles dealing with appliances for the prevention and combating of fire and news of fire brigades and ambulance and first-aid services.

Galvanometers.—A comprehensive catalogue of galvanometers, explanatory and fully illustrated, has been issued by the Cambridge Scientific Instrument Company, Limited, Cambridge. These include the Ayrton-Mather, Paschen, Broca, Thomson, Einthoven and other types of galvanometer, as well as other instruments manufactured and supplied by the company.

Heavy Machinery.—The Mesta Machine Company, Pittsburg, Pennsylvania, U.S.A., specialise in machinery of the monster type for the steel industry, including rolling mills; hydraulic forging, shearing and bending machines; large gas and steam engines; the production of heavy iron, steel and bronze castings and the machining of them. Their catalogue gives a large number of handsome illustraticns of these and other machines and parts with a very informing letterpress description.

Electric Motor Generators.—These machines are for transforming the supply current to a current of the kind and voltage required for use. They consist of a motor and generator on a single base plate directly coupled; for example, an A.C. motor taking a supply at 50 periods and 480 volts and a D.C. generator delivering current at 115 volts. Examples are shown in a catalogue leaf from the British Westinghouse Company, Limited, Trafford park, Manchester, who are makers of a large range of combinations and powers.

War Record.—Amongst records of engineering war work, that of Messrs. Ruston and Hornsby, Limited, of Lincoln, Grantham and Stockport, must be placed in the front rank. Like those of other great British firms it is remarkable for both quantity and variety. It again illustrates the fact that the large British engineering firms had in pre-war times been able to specialise in production in accordance with commercial requirements while retaining their full range of ability as engineers. This record shows, what was already well known, that when the call of war came the Ruston and Hornsby firms (now one firm) almost immediately took first rank as builders of airplanes, while expanding their output of heavy road engines; steam, gas and oil engines and many classes of machinery which are necessarily of sturdy build—in fact, the most striking contrast to aircraft. For land warfare they produced light gun carriages of all kinds, carts and trailers, portable cooking, washing and sanitary equipments and even portable pigeon lofts, gun-sighting and training gear, caterpillar tractors, gas and flame projectors, besides shells and bombs in enormous quantities; 28,000 lorry and artillery wheels and 600,000 horse shoes are other items. Submarine and aircraft engines, steam boilers of all kinds, naval mines, paravanes and mine-sweeping appliances also figure in large quantities. These are only briefly referred to in the record, which mainly consists of illustrations, and makes no attempt to claim credit for the difficulties encountered in supplying the war service requirements. A non-technical reader may reasonably ask why such a firm spread its energies over such a variety of work when it might more profitably have concentrated on a narrower selection. The answer is that profit was not the ruling factor: the war services were in sore need of the various products. It was in the old-established and well-organised engineering firms that the talent for design, workmanship and rapid production was found of a quality capable of new tasks, and there, too, was the willing spirit.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are give in italics.

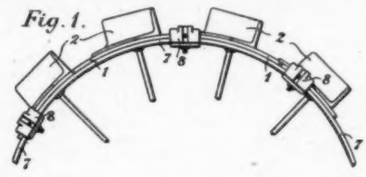
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

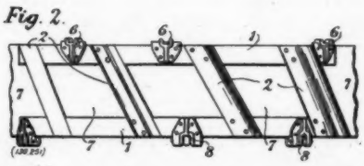
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AGRICULTURAL APPLIANCES.

130,251. H. Garner, Moseley, Birmingham, and J. P. Garner, Sparkhill, Birmingham. Motor Tractors. (9 *Figs.*) November 30, 1918.—The invention refers more particularly to that class of motor tractors which are designed for agricultural purposes and the wheels of which are provided with supplementary rims made in sectional lengths and provided with gripping media, said supplementary rims being adapted to be detachably secured to the main rim of the wheel. One of the objects of the invention is to provide improved retaining means for the supplementary rim sections, and in accordance therewith the sections are provided at one edge with fixed hook members adapted to hook over the inner edge of the main rim, and at the opposite edge of each section are provided movable hook-like clamps adapted to engage with the outer edge of the main rim. The supplemental rim is preferably of skeleton form, comprising two narrow strips 1, 1, bent to the curvature of the

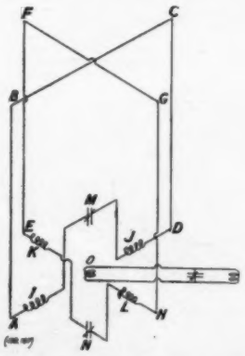




road rim and connected by inclined gripping media, which may conveniently take the form of the angle-iron strakes 2. The fixed hooks 6 are secured to one of the bands 1 and are arranged to embrace the inner edge of the road rim 7. The movable clamps 8 are secured to the second supplemental band portion 1 and comprise a fixed portion riveted to the band 1. To this fixed portion is pivoted a movable part preferably by means of a screwed eyebolt. The movable part is provided with a projecting part preferably of tapered or wedge form, which engages a corresponding recess in the fixed part so as to positively lock said movable part against angular movement when screwed up tight by means of a controlling nut carried by the pivoted eyebolt. Thus the parts cannot be disconnected until the nut has been retracted sufficiently to disengage the interlocking parts of the movable jaw and fixed member. (*Accepted August* 6, 1919.)

ELECTRICAL APPARATUS.

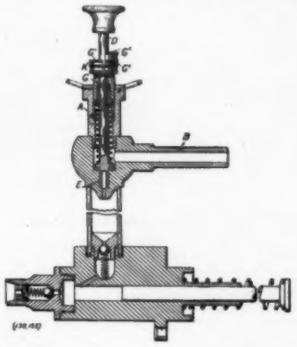
130,107. [Marconi's Wireless Telegraph Company, Limited, London, and H. Richmond, London. Wireless Telegraphy. (2 *Figs.*) April 25, 1918.—This invention relates to apparatus for eliminating interference in wireless telegraphy, whereby signals coming from a different direction from that of the signals it is desired to receive may, even though of the same wave length, be eliminated without materially reducing the



strength of the desired signals. It is well known that if a receiver be connected to a coil which can be rotated in two independent fields produced by two directional aerials at right angles to each other, there is a position of the coil in which no sound is caused by signals from a particular direction. According to the present invention, and with the object of avoiding reduction in the strength of the desired signals, an unsymmetrical field for the coil is produced by adjusting the coupling between the coil and the two aerials so as to strengthen one of the two component fields and/or weaken the other. A, B, C, D and E, F, G, H are two frame aerials situated at right angles to each other. These aerials may be rectangular or may consist of directive systems of any known type. In these aerials are connected inductances I, J, K, L, and condensers M, N. An inductance O is coupled to the coils I and J and to the coils K and L, and is connected to the receiving circuit. The distance of I, J, K, and L from O can be adjusted so that the coupling between each aerial and the receiving circuit may be varied independently so as to produce an unsymmetrical field. In practice it is preferable to set out the aerials so that the plane of one frame lies in the direction of the station it is desired to receive, the other being at right angles to this direction. It is also essential that the coils I and J should be so situated with respect to K and L that no mutual action can occur between them. In use it is found best to have the receiving aerial as loosely coupled as possible without unduly weakening the receiving signals, and the balancing aerial as tightly coupled as possible. This arrangement also reduces to a minimum the effect of any mutual action between the two circuits. The two aerials should be tuned to exactly the same frequency. When this condition obtains the currents produced in the two aerials by a jamming station will be identical in phase and by adjusting the positions of the coils I, J, K, L, a position can be found for the coil O such that the effects produced in the two aerials by the signals from that station are equal and opposite on the receiving circuit, and consequently no indication results from them in the receiver, whilst the signals to be received are not unduly weakened. (*Accepted August* 6, 1919.)

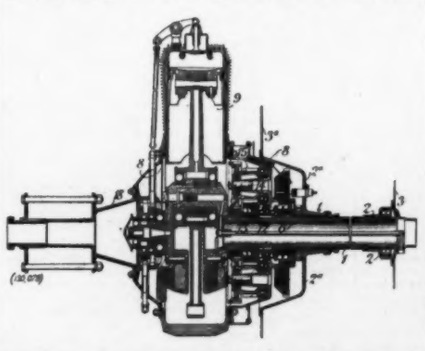
GAS ENGINES, PRODUCERS, HOLDERS, &c.

130,155. J. F. Collard, Tidworth, Andover, and H. Brettell, Tidworth, Andover. Lubricators. (1 *Fig.*) July 25, 1918.—This invention relates to cocks or valves for controlling the flow of fluids, such for example, as the oil feed to a lubricator pump for an internal-combustion engine. According to the present invention, a cock or valve comprises the combination with a tubular chamber A having an outlet at one end and an orifice for the delivery thereto of the fluid to be controlled, of a spring-controlled spindle D arranged in said chamber, one end E of said spindle being hollow and pierced with one or more holes and fitting the outlet at the end of the tubular chamber A, and the other end having a transverse projection K and being supported in a bush G screwed into the open end of the tubular



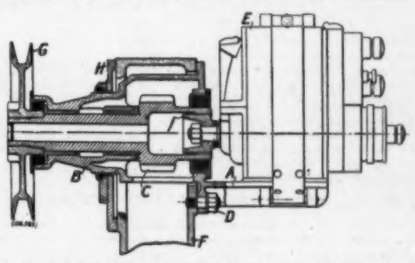
chamber, said bush being cut away at the top so as to provide a plurality of faces G^1, G^2, at different levels, on which faces the projection on the spindle may rest for the purpose of supporting it at different levels. Preferably a second tubular member B is arranged at an angle to the first chamber A and communicates therewith, said second tubular member constituting the delivery means for the fluid to be controlled, and being preferably screwed at the end for attachment to the fluid-supply tank. The bush G may also be slotted at G^3 to accommodate the projection K on the spindle for the purpose of allowing the spindle to take up a position with its hollow perforated end E within the bottom end of the tubular chamber, and thus allow the flow of fluid to be entirely stopped. (*Accepted August* 6, 1919.)

130,078. The Daimler Company, Limited, Coventry, A. E. Berriman, Coventry, and J. Dixon, Coventry. Internal-Combustion Engines. (1 *Fig.*) January 15, 1918.—This invention relates to internal-combustion engines in which the cylinder unit revolves in one direction, and the crankshaft unit revolves in the other direction. The engine is supported upon a tube 1 fixed to and extending from brackets 2 and 2a, secured to stationary supporting members 3 and 3a, and the supporting tube 1 carries bearings located at a distance apart,



one adjacent to the bracket 2 and the other bearing near the inner end of the tube 1. These bearings support the crankshaft element 6 of which the cranks form a part, while the gear-box and crank casing 8 and the cylinders 9 revolve on bearings supported by the tube 1 and on bearings supported upon the long end of the crankshaft as closely as possible to the crank. The two pivotally-rotating units, that is the cylinders 9 with the gear-box 8, and the crankshaft 6, are geared together through the intermediary of the tube 1, that is the tube 1 is formed with a gear member 12 upon the inner end of the tube 1, while the crankshaft 6 is formed with a gear member 13. Rotatably carried upon each axle 14 fixed to the gear-box 8 is a composite gear wheel 15, one set of teeth of which gear with the gear member 13, while another set of teeth gear with the stationary gear member 12 carried by the tube 1. Thus the cylinder unit 9 comprising also the gear-box and crank casing, revolves in one direction, and the crankshaft unit 6 revolves in the other direction, and the entire power of the engine is delivered to a propeller or the like fixed upon one of the rotating members, in the manner shown, consisting of the members 18 fixed to the crank casing, and consequently revolving with the cylinders. It will be observed that the gear is of epicyclic type, and the gear ratio is preferably such that the crank chamber unit, that is the cylinders 9 and the crank casing of the gear-box 8, are constrained to rotate equally and in an opposite direction to the crankshaft unit 6. (*Accepted August* 6, 1919.)

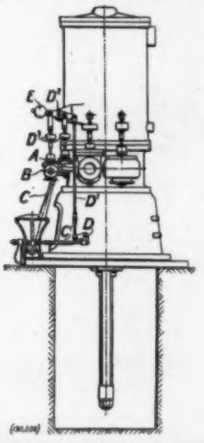
130,289. Crossley Motors, Limited, Gorton, Manchester, and T. D. Wishart, Heaton Chapel, Stockport. Internal-Combustion Engines. (1 *Fig.*) March 3, 1919.—This invention relates to improved means for supporting ignit on apparatus in internal-combustion engines. A designates the magneto platform formed in one piece with the bearing support B; C the chain wheel and driving shaft for the magneto; D one of the studs, any suitable number of which may be used for securing the combined bracket to the chain case; E the magneto;



F the chain case, which is usually made in one piece with the crank-case, not shown; G a driving pulley which may be used in any convenient way, as, for example, to drive the lighting installation, but is not necessary to this invention; H the cover for the driving chain, by the removal of which access may be obtained to the chain; and I an easily-detachable coupling between the driving shaft and the magneto shaft; any other suitable form of coupling may be employed. (*Accepted August* 6, 1919.)

HYDRAULIC MACHINERY.

130,226. Duncan Stewart and Co., Limited, Glasgow, and T. E. Holmes, Glasgow. Controlling Gear. (3 *Figs.*) October 16, 1918.—The invention relates to steam-hydraulic intensifier operated presses, shears and the like of the type in which the press head is raised by steam pressure and its rising controlled by a valve in the exhaust from the hydraulic cylinder or cylinders. According to the invention, the valves A, B, controlling the steam supply to the lifting cylinders are so operatively connected to weights E, D^3, springs or equivalents, that the valve B controlling the exhaust from those cylinders is normally closed, while that controlling the inlet of steam to them is normally open. Thus there is normally exerted by the steam in the lifting cylinders a pressure tending to raise the press head or equivalent part of the machine. The

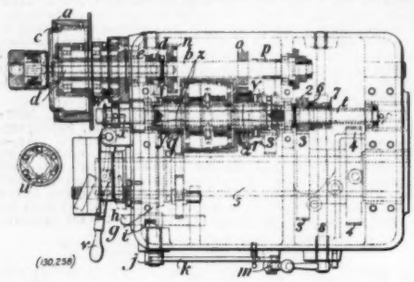


valve gear controlling the valves of the intensifier is of any convenient form and is operated by a usual hand lever C. This hand lever is so connected to the valves A, B, of the lifting cylinders through a lost-motion device, comprising a tappet lever operated by the hand lever and engaging alternatively two tappets on a rod C^1. The rod C^1 is connected through a bell crank lever D and a link D^1 with a rocking lever D^2 connected to the valves A, B. In operation the exhaust valve B is normally held closed by the weight D^3 on the spindle of that valve, whilst the inlet valve A is normally held open by the rocking lever D^2. When the hand lever C is thrown over to the position shown the exhaust valve B is held open and the inlet valve A closed against the pressure of the weights holding them in normal position. (*Accepted August* 6, 1919.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

130,258. J. Macnab, Bredbury, near Stockport, and G. H. Smith, Bredbury, near Stockport. Multi-Speed Headstocks. (2 *Figs.*) December 11, 1918.—This invention relates to multi-speed headstocks for lathes. *a* is the power pulley, and it drives the shaft *b* through the friction clutch *c* which is controlled by the push rod *d* operated by the collar *e* and crank arm *f* upon the spindle *g*. The latter may be turned through the medium (1) of the rod A, which engages the crank arm *i* upon the spindle *g*, or (2) of the crank arm *j*, connecting

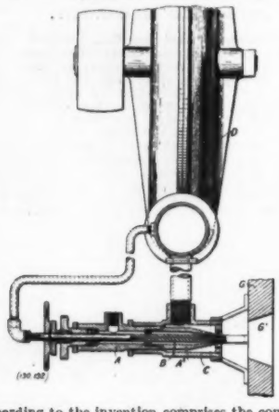
link k and handle m. The shaft b carries two gear wheels n and o, and integral with the shaft is the pinion p. Continuously in mesh with n, o, and p, are the gear wheels q, r and s; q and r driving the shaft t through spring-loaded friction clutches and s driving the said shaft through a ratchet wheel u as shown in the small figure at the left of the drawing, when the gears q and r are inoperative. The latter are controlled by the handle v, spool w, rod x having inclines y, and the levers z. The ratchet gear u is the slowest speed gear. The shaft t carries a double



pinion 2 which can be moved into engagement with either pinion 3 or pinion 4 upon the driving shaft 5. The sliding of the pinion 2 is effected through a collar 6 operated from the spindle 8 by a crank arm 7. The arrangement described provides six speed changes, in two ranges of three. The handle v and the rod h may be actuated automatically in any ordinary manner for changing the speed of the shaft 5 and for declutching the driving pulley respectively. The handle v controls the three speed changes on the shaft t. (*Accepted August* 6, 1919.)

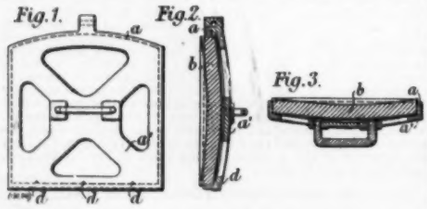
MINING, METALLURGY, AND METAL WORKING.

130,132. J. A. Curle, South Hackney, London, and W. Sellar, South Hackney, London. Liquid Fuel Burners. (2 *Figs.*) July 19, 1918.—This invention relates to apparatus for atomising and burning liquid fuel by means of a burner of the type comprising three concentric nozzles, the intermediate for the supply of fuel, and the outermost and innermost for the supply of air; the innermost nozzle co-operates with the intermediate nozzle to constitute a valve for controlling the flow of fuel between the same, and these two nozzles are circular in form, one or both being coned; the liquid fuel thus escapes in the form of an annular jet which is atomised into spray by the air from the two air nozzles. Apparatus for atomising and burning liquid



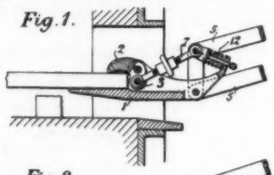
fuel according to the invention comprises the combination with a liquid fuel burner of the type described arranged in operative relation to an aperture G1 in a wall of a furnace G, of a fan D or other low-pressure rotary air compressor for supplying low-pressure air to the outer and inner air nozzles C, B, of the burner, the total effective area of the orifices of which air nozzles is so much larger than that of the orifice of the fuel nozzle A2 that at the low pressure of air supplied by the fan, a sufficient or nearly sufficient volume of air can be sent through the burner to effect the complete combustion of the fuel for the purpose of reducing the cost of the apparatus as compared with that of apparatus comprising high-pressure air compressors. (*Accepted August* 6, 1919.)

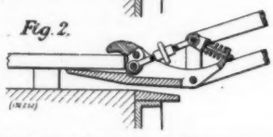
130,216. A. T. Nutt, Darnall, Sheffield, and F. A. Harvey, Nether Edge, Sheffield. Metallurgical Furnace Doors. (4 *Figs.*) October 7, 1918.—This invention relates to the construction of doors for metallurgical and like furnaces. In doors made according to this invention the rectangular flanged metal frame a is made with an outwardly-curved back $a1$ arched both longitudinally and vertically (see Figs. 2 and 3), so that the metal



portion of the door has a concave face nearest the furnace. Before a door is lined with bricks b, a layer of sand is inserted to fill up the space between the concave face of the metal $a1$ and the rear face of the brickwork lining b, and so temporarily support the latter. Two or more small holes d are formed through the metal near the bottom of the door, for a purpose to be hereafter explained, which holes are filled up until such time as the door is to be put into use. The brickwork lining b itself, is formed concave-convex, *i.e.*, concave on the side nearest the furnace and convex on the reverse side, between which and the metal back of the door is placed a layer of sand. When one of the improved doors is placed in position on a furnace, the stopping is removed from the holes d, and as the heat of the furnace causes the brickwork lining b to expand, the predominant tendency (by reason of its shape) is for it to bulge outwardly, into the cavity behind. The influence of the heat also causes the sand to dry and disintegrate and run out through the holes d provided in the bottom portion of the door. In this way the distortion of the brickwork does not interfere with the satisfactory fitting of the door, and any tendency to breakage of the metal castings from the same cause is also obviated. (*Accepted August* 6, 1919.)

130,252. A. W. Jones, Stepps, J. Bryan, Gartcosh, and A. J. H. Mowbray, Stirling. Ingot Manipulators. (7 *Figs.*) November 30, 1918.—The subject of this invention is a grip for handling slabs, bars, billets, piles, plates or other articles. Broadly stated, the invention consists in a grip comprising two differentially-movable jaws so arranged that movement of one jaw directly by pressure of the load is accompanied by movement of the co-operating jaw through a relatively greater distance into clamping engagement with the load. In a preferred embodiment the grip comprises a lower jaw 1 and an upper jaw 2, 3, the lower jaw being constituted by an arm pivotally mounted on a grip sustaining jib 5, and the upper jaw

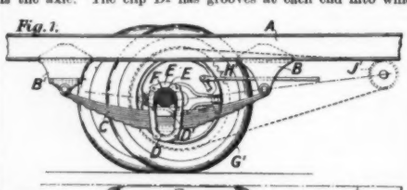


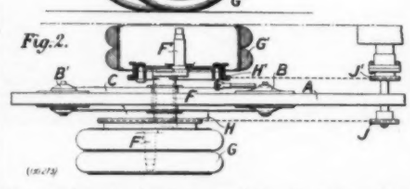


being constituted by a bell-crank lever fulcrummed on the arm 1, one arm 2 of such bell-crank lever presenting a jaw surface and the other bell-crank lever arm 3 being connected by a link 7 to the jib 5 at a point remote from the point of pivotal attachment of the lower jaw 1 to the jib 5, and means such as a spring 12, weight or the like for maintaining the jaws normally in open position, the arrangement being such that pressure acting downwardly to move the lower jaw 1 is accompanied by rocking movement of the bell-crank lever under the control of the link 7, and in opposition to the spring, weight or the like into clamping relation with the lower jaw. Desirably the effective length of the link 7 is variable to permit the grip to be adjusted for loads of different thickness. (*Accepted August* 6, 1919.)

MOTOR ROAD VEHICLES.

130,273. J. T. Roberts, London, and L. Johnson, London. Road Wheel Axles. (2 *Figs.*) January 30, 1919.—The primary feature of the invention consists of a vehicle having two road-wheel axles arranged to rock in their bearings one at each side of the vehicle, each axle having two cranks, one at each end thereof —the two cranks being disposed on opposite sides of a vertical plane passing through the axis of rocking of the axle, and each carrying a road wheel. Connected to the chassis A by brackets B, B1, is a leaf spring C at each side of the vehicle, and mounted on this leaf spring by clips D, D1, frames E, and a bearing E1, is the axle. The clip D1 has grooves at each end into which

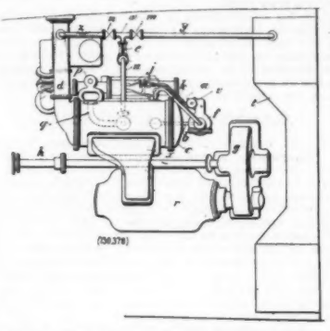




the ends of the bearing E1 are received. The axle consists of a body F mounted to rock in the bearing E1 and arms F1, F2, on which are carried the road wheels G, G1. The arms F1, F2, are cranked and are disposed on opposite sides of a vertical plane passing through the axis of rocking of the portion F. The road wheels may be arranged to be driven by their sprocket wheels H, H1, gearing by chains with driving wheels J, J1. The arms F1, F2, are arranged at such an angle relatively to each other that when the axle is in its median position, the axis of the arm F2 lies in the direct line between the axis of the wheel J and the axis of the body F. (*Accepted August* 6, 1919.)

SHIPS AND NAUTICAL APPLIANCES.

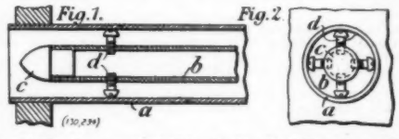
130,378. G. and J. Weir, Limited, Cathcart, Glasgow, and C. R. Lang, Cathcart, Glasgow. Steam-Turbine Propelled Vessels. (2 *Figs.*) February 5, 1918.—This invention is intended to be applied to the propelling machinery of steam turbine propelled vessels and relates to condensing plant which comprises a condenser, a steam-driven boiler-feed pump arranged to draw the water of condensation from the condenser and discharge it direct into the boiler, a float control device arranged to control the supply of steam to the feed pump—and so to control the speed of the pump—in accordance with the water level in the condenser, and an ejector arranged to withdraw the air from the condenser. The invention consists in an arrangement and combination of condensing plant as above mentioned for steam turbine propelled vessels, characterised by the arrangement and provision of means whereby the air ejector can (and in working normally will) discharge into the feed tank, but can, if and when desired, be caused to deliver into the circulating water discharge from the condenser. r is the main turbine, h the propeller shaft, g the gear-box which contains the gear wheels by which the turbine drives the propeller shaft, c is the condenser, x the exhaust pipe leading from the turbine to the condenser, d the circulating water discharge from the condenser to the sea, fi the float-box, p the boiler feed pump, e the ejector, and t the feed tank. The float-box f is connected to the condenser by the pipes a, b, so that the water level within the box is the same as the level of condensed water in the condenser, and the float is so arranged within the box and so provided with mechanism that the rising of the float opens the valve v which is situated on the steam pipe k which conveys steam to the engine j which drives the pump p, while the fall of the float acts to close the valve. By this means the condenser is prevented from ever being quite emptied of water of condensation, the water outlet pipe q which



leads to the suction of the feed pump being always sealed. The ejector e draws air from the condenser through the pipe u and discharges it into the T-pipe w, whence the air with vapour passes either to the feed tank t by way of the pipe y or to the circulating water discharge d by way of the pipe z. Hand-controlled valves m and n are placed respectively on the pipes y and z to control the discharge. It is intended that the ejector should normally discharge through the pipe y into the feed tank for the double reason of economising heat and economising feed water; but, when the feed water in the tank is too hot to allow additional heat to be given to it, or when, for other reason, it is undesirable to discharge into the feed tank, the valve m is closed, the valve n opened, and the discharge takes place into the circulating discharge pipe d. (*Accepted August* 13, 1919.)

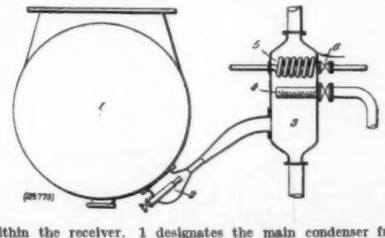
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

130,234. P. St. G. Kirke, Westminster, London. Multitubular Boilers. (3 *Figs.*) October 30, 1918.—The invention relates to a method of constructing an efficient horizontal or vertical muiti-tubular waste-heat boiler which consists in making it shorter or lower than is consistent with efficiency, supplying its tubes with cores making up the sectional area for the passage of gases by increasing the number of tubes, and correspondingly increasing the draught. a is the fire-tube, and b is a core tube. The latter is closed at the end which is met by the gases, entering the fire-tube, the preferred stopper c being



shaped like the nose of a shell having its widest diameter equal to the external diameter of the tube and adapted to fit into the end of the tube. According to the invention, the radial arms which support the core tube are of adjustable length, so that the tube may be suited for fire tubes of slightly varying bore, or may be mounted eccentrically in the fire-tube. The drawing shows screws d constituting these arms, of which there may be two sets placed respectively at a quarter to three-quarters of the tube length, since thus each set will take half the weight of the tube and sagging will be less likely to occur. (*Accepted August* 6, 1919.)

129,775. D. B. Morison, Hartlepool. Steam Condensing Plant. (3 *Figs.*) July 9, 1918.—This invention relates to steam condensing plant of that general character in which the supply of water for condensing the steam or vapour discharged by a steam operated ejector device, is supplemented when a given temperature is exceeded. The present invention consists in providing a condensing receiver maintained under a vacuum less than that in the main condenser into which the steam is delivered and condensed mainly by condensate from the main condenser, with a supplementary condensing device to which a cooling medium is made to flow when the desired temperature associated with a given absolute pressure is reached or exceeded



within the receiver. 1 designates the main condenser from which aerated vapour is drawn by the steam jet ejector 2 and delivered to the condensing receiver 3, supplied through the perforated pipe 4 with condensate or other water intended for boiler feeding purposes in accordance with known practice. Within the condensing receiver 3 is a supplementary condensing device 5, shown, by way of example, in the form of a coil through which condensing water can flow under control of a hand operated valve 6. It will be clear to those conversant with condensing plant in general that should the temperature within the receiver rise from any cause beyond limits permissible in practice, the valve 6 can be opened, and the temperature reduced to any desired degree. (*Accepted July* 30, 1919.)